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An investigation into computer programming as an academic discipline which provides education for both sides of the brain.

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AN INVESTIGATION INTO COMPUTER PROGRAMMING AS AN ACADEMIC DISCIPLINE WHICH PROVIDES EDUCATION FOR BOTH SIDES OF THE BRAIN

A Dissertation Presented

By

SALLY A. COPPUS

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Education

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DEDICATION

To my parents, Gerry and Bill, who have encouraged my strengths and inspired in me an enthusiasm for living;

To my sister and brother-in-law, Judy and Jim, who helped me realize at a young age the value of independence;

To my grandmothers, Rosetta and Etta, two women from another generation whose lives encouraged my own liberation;

To my grandfathers, Clarence and David, both of whom enjoyed to work and instilled the same appreciation in me;

And, finally, to Holly, Robin, Eileen, Helen, Civilla and Harold, all of whom provided warmth and support.

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ABSTRACT

AN INVESTIGATION INTO COMPUTER PROGRAMMING
AS AN ACADEMIC DISCIPLINE WHICH PROVIDES
EDUCATION FOR BOTH SIDES OF THE BRAIN

(May 1978)

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Recent research findings demonstrate that, for most individuals, the left cerebral hemisphere involves logic, language, and sequential-analytic thought while the right is responsible for intuitive, spatial, imaginative, and holistic thought. The complementary workings of these two modes of knowing result in both analytic and intuitive capabilities of a fully functioning consciousness.

How student-controlled computing can develop the skills of the right hemisphere to the same extent as those of the left is the major concern of this study. The process of conceptualizing, designing, implementing, and debugging a computer program can be viewed as an active interplay of right and left brain abilities.

To investigate the topic, the author designed and offered a six-week summer course--"Introduction to Computers and A Programming Language"--to ten students from the Upward Bound Program. The majority of students had no exposure to mathematics beyond beginning algebra.

Data were collected concerning the variables of achievement in and attitude toward computer programming, academic self concept, computer programming behaviors, and mode of cerebral hemispheric operation. An examination of these variables provides an information base concerning how educators might view and utilize computer programming as an area of appeal for all students.

The investigation used data collected from the following instruments: (1) "Your Style of Learning and Thinking," a self-report instrument available from the University of Georgia, Department of Psychology--used to ascertain participants' relative use of the right, left, or integrated modes of hemispheric operation; (2) "APL Assessment," constructed by the author to appraise participants' knowledge of A Programming Language; (3) "An Opinion Survey: How Do You Feel About Computers," designed by the author to assess participants' attitudes toward computers; (4) "The Michigan State General Self Concept of Ability Scale"--by Wilbur Brookover at Michigan State University--selected to assess students' academic self concepts; and (5) "Programming Style," designed by the author to identify behaviors during various aspects of the computer programming process.

A combination of correlational (Pearson product-moment) and descriptive (frequencies, means, and standard deviations) statistics were used in data analysis.

Results of the exploratory study indicated that, for the sample of ten students under study, greater use of the "left" and "integrated" modes of cerebral hemispheric operation was related to higher achievement in and more positive attitudes toward computer programming and more positive academic self concepts than use of the "right" mode. Analysis of programming behaviors indicated that students in the "right" group expressed greater ability to think of a program "as a whole" and preferred programming projects involving words, pictures, and poems. These students also became more easily frustrated and relied on the instructor for assistance. Students in the "left" and "integrated" groups maintained greater control and were more tolerant of the step-by-step procedures in constructing and debugging their programs. All students did become actively involved in the course and opened themselves up to interaction with the computer, through programming.

That the computer is an educational tool that can be used by <u>all</u> students for their own intellectual development, regardless of their hemispheric or academic preference, has implications for the general use of computers in education. Students who had avoided highly analytic courses did find an appealing outlet for their abilities and interests in computer programming. When the computer is a powerful influence on daily life in our society, giving <u>all</u> students access to the skills needed to control it results in their not only acquiring a "survival skill," but also in their becoming involved in an <u>active</u> process of developing their full conscious potential.

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CHAPTER I

INTRODUCTION

> Our schools have been focusing most of their resources on tutoring only the left half of the brain. To develop all of a child's capacities we must have curricula and materials for both sides of the brain, and we must cultivate the ability to use these two different minds in a complementary way.
>
> -- Robert Ornstein

Recently, educators have become interested in the concept of duality of mind that has been depicted in literature and the arts, questioned in philosophy, and investigated in psychology and medicine over the past century. The concept implies that for most individuals there are two complementary modes of knowing: one, a verbal-intellectual mode which involves logic, language, and sequential-analytic thought and is controlled by the left hemisphere of the brain; the other, an intuitive mode, is controlled by the right hemisphere and involves imaginative, spacial, and holistic thought.

Most people possess a fully functioning consciousness and alternate between the two modes, selecting whichever one is most appropriate for a given cognitive task. The complementary workings of the two modes seems to result in both analytic and intuitive capabilities. However, it is possible that one hemisphere may become dominant (perhaps by excessive use or training) which results in the other being stifled.

The opening quotation (Ornstein, 1977) suggests that education in the United States is highly oriented toward left-brain (verbal, logical, analytic) functioning. Several other authors (Bruner, 1962; Hunter, 1976; Rennels, 1976; and Samples, 1975) support this position, indicating that classrooms have traditionally encouraged and reinforced the rational, academic mind that articulates a reason for all it does. The "back-to-basics" curriculum movement, popular in the 1970's, which emphasizes skills in reading, writing, and arithmetic, epitomizes this all too well. Another example, from the 1960's, is the compensatory education concern which placed a major emphasis on providing adequate experience with reading materials for "disadvantaged" children prior to coming to school.

On the other hand (or hemisphere), curriculum areas that are intended to enhance creative, spatial, and imaginative skills of the right hemisphere, such as art, music, and movement, are ancillary considerations in schools. When budgets must be cut, teachers of these disciplines are often the first to be displaced, and right-brain materials and methods are the first to go. Some schools have such offerings only as extracurricular activities. And how often is it the case that students are deprived of art or gym if they misbehave in reading or mathematics?

An educational system in which creative expressions and intuition are secondary to developing basic skills discriminates against one half of the brain. It would seem that, in order for the full potential of the mind to be actualized, the imaginative, spatial and holistic skills of the right hemisphere must be developed to the extent of the verbal, rational, sequential ones of the left.

A problem facing today's educators is how to go about educating the "other side" of the brain--how to stimulate, encourage, and develop creative capacity. By providing opportunities for inventiveness and the use of intuition, schools can stimulate right cerebral abilities to complement the rational skills of the left.

Rationale and Theoretical Overview on Which the Problem Is Based

Research supporting the theory of specialized cognitive functions for each hemisphere of the brain has been accumulating for some time. In the early 1950's, experiments were performed on brains of lower animals and a decade later surgery was performed on the brains of human beings suffering from epileptic seizures. In all experiments, the operations involved severing the "corpus callosum" which is a mass of interconnecting fibers that joins the two hemispheres of the brain and provides for information from each to be passed to the other. In the split brain patients, the right hand literally did not know what the left was doing. Studies completed with the "split-brain" patients confirmed two separate conscious minds in one head, the left for verbal and analytic thought, the right for intuition and understanding patterns. (A more thorough account of these experiments is included in Chapter II.)

Further research with "normal" persons, that is, persons whose corpus callosums were not cut, also resulted in the conclusion that the two hemispheres specialize in two kinds of thought. However, in these experiments, the "in-tact" corpus callosum transmits messages from one hemisphere to the other and produces integrated brain functioning which results in each hemisphere being augmented by information processed by the other (Ornstein, 1972).

Madeline Hunter (1976) provides a useful analogy for understanding integrated cognitive functioning. She compares "brainedness" to "handedness". Most persons use one hand or the other for certain tasks, e.g., they hold a tennis racket in the right hand but toss a tennis ball for a serve with the left. No matter how adequate the right hand is, most things are done more effectively if the left is also used. Individuals may be predisposed to use their right or left hands, but practice has a great deal to do with skills, e.g., right-handed pianists who play beautifully with their left. Without practice, skills are not developed so that the facility of the dominant hand results in minimal use of the subordinate one.

Continuing the analogy, the same may be true of "brainedness". Students having the ability to "picture" how a model airplane fits together (using their right brains) may not give their left brains an opportunity to exericse by reading and following directions. Conversely, students who insist on being told directions rather than following a map are not exercising their right hemispheres.

Our schools have been gearing most instruction through left-brained input (reading and listening) and output (talking and writing) and consequently are handicapping all students (Hunter, 1976). Those who learn well with this left-brained structure have had minimal opportunity for developing their right brains. Those who learn more easily with right-brained activities are handicapped. This perspective has many implications for viewing the "slow-learner", i.e., perhaps it is the educator who has been slow to learn what methods or materials may facilitate learning for a particular student. Such a perspective provides a mandate for educators to present information so that students have the opportunity to use both their hemispheres.

Richard Konicek (1975) contends that the integration of the two hemispheres of the brain has a synergic effect--"the output of the two minds can be equal to more than the sum of the two halves" (p. 37). Educators continue to be concerned that schools do not allow children to reach their full potential. Now that we have data that two parts of the brain exist, each with different specialized abilities, the key to developing unlimited potential (given the synergic effect) may be in providing learning environments for educating both sides of the human mind.

Statement of the Problem

Precisely how the schools of western society can adjust the curriculum so that it stimulates, encourages, and develops spatial and imaginative abilities to the same extent that it develops verbal and analytic skills, is the major concern of this dissertation. More specifically, the author will examine computer programming and investigate whether it can be considered as an academic discipline which allows students to utilize their full conscious potential by providing opportunities for them to use both analytic and holistic cognitive abilities. The investigation will explore the relationship between mode of cerebral hemispheric operation and achievement, attitude, academic self concept, and "computing style" of student computer programmers.

The position that computer programming is something other than a left-brained (analytic, logical) pursuit is not generally present in literature concerned with instructional applications of computers. Much of the literature concerning the use of computers in education addresses their application as "teaching machines", that is, as controlling mechanisms which facilitate the teaching of skills and the management of learning tasks. This use is not relevant to the proposed study. Rather, the author is interested in students' learning to program (control) the machine for their own problem-solving attempts and intellectual development.

Successful computer programming requires the need for analysis and the ability to formulate logically sequenced algorithms. However, it also provides the opportunity to brainstorm problem solutions, actively test them, refine them, adapt them, and discover new ones. The process of conceptualizing, designing, implementing, and "debugging" a program can be viewed as an active interplay of right and left brain cognitive abilities which becomes an exercise for a fully functioning consciousness.

This idea of "student-controlled", active computing has been and is the focus of many computer projects. The philosophy of these projects provides a basis for the problem under study. A synopsis of some of the projects is included here, however a more thorough discussion follows in Chapter II.

Thomas Dwyer, director of Project Solo at the University of Pittsburgh, advocates learner control of the computer and discusses the act of programming as a means of "liberating human potential". Students begin their programming experiences in a "dual-mode" by interacting with already written computer programs. They have to apply a set of "heuristic" strategics--principles or guidelines that help them make decisions and discoveries--to these programs on their way to "solo mode" in which they have total control over the computer (Dwyer, 1971).

Howard Peelle's "Glass-Box" approach to programming at the University of Massachusetts also has implications for exercising both right and left hemispheres. This technique involves the writing of programs such that their inner workings are "visible" and encourages a holistic view of the specific components of algorithms (Peelle, 1974b). This approach was used by Portia Elliott in her work with teacher training. She applied glass-box programs in teaching elementary school teachers concepts in mathematics and pedagogical strategies for their use in teaching children mathematical concepts and algorithms (Elliott, 1973).

The work of Seymour Papert at the Massachusetts Institute of Technology also addressed the exciting opportunities computers offer in the teaching/learning process. In Papert's Project LOGO, students become creatively involved in exploring the possibilities of devices such as a mechanical "turtle" in a way that learning is natural and active, and a blend between spatial/holistic and analytic/algorithmic thought (Papert, 1972).

Finally, Arthur Leuhrmann, director of Project COMPUTe, recommends that "the student should teach the computer" (and not the converse) so that the full potential of the machine and student are not wasted. This "computer as pupil" use of computers in education allows students to become masters of computing, not merely its subjects (Luehrmann, 1972).

Purpose of the Study

The primary intent of this dissertation is to address the "Ahah!" experience that occurs in the process of computer programming. This activity of the right hemisphere, coupled with the skill of the left in formulating a logical, sequential algorithm, comprises an exercise for the whole brain of student programmers.

In order to provide information concerning this view of computer programming, the investigator offered a six-week introductory computer programming class to high school students during the summer of 1977, at the University of Massachusetts. Data collected included student self reports of the use of "right", "left", and "integrated" modes of cerebral hemispheric operation; assessments of achievement in, and attitude toward, computer programming; a measure of academic self concept; and finally, student self reports of their specific behaviors during various aspects of the computer programming process. The results of data analysis are intended to present evidence that computer programming is an academic discipline which offers exciting and creative "holistic" learning opportunities for all students, regardless of which mode of cerebral hemispheric operation they prefer.

Research Questions

The underlying hypothesis of this study is that computer programming provides education for "both sides" of the brain. To develop the topic, the investigator explores the relationship of left-, right-, and integrated-brain functioning with success in and attitude toward computer programming and academic self concept. In addition, the investigation includes a discussion of specific behaviors during computer programming, related to mode of cerebral hemispheric operation.

Specific questions which the exploratory research addresses are:

(1) Is there a relationship between mode of cerebral hemispheric operation and achievement in computer programming?

(2) Is there a relationship between mode of cerebral hemispheric operation and attitude toward computer programming?

(3) Is there a relationship between mode of cerebral hemispheric operation and academic self concept (in student computer programmers)?

(4) Is there a relationship between mode of cerebral hemispheric operation and specific aspects of the computer programming process?

Implications of the Study

During this age of technology when the computer significantly affects the daily lives of most citizens, there is a strong rationale for including knowledge of its capabilities and limitations (computer literacy) and skills in using it (programming) in the education curriculum. If the results of this study support the fact that computer programming is an academic discipline that provides education for both halves of the brain, there would be a much more dynamic reason for including programming in the academic program of all students. That is, along with acquiring a "survival skill", students will be involved in an active process of developing their full conscious potential.

This view of the computer as an educational tool to be used by students for their own intellectual development will hopefully lend a fresh prospective to the general use of computers in education. In the late 1960's and early 1970's, there was much excitement and controversy over the role computers might play in the classroom--some predicted that computers used as teaching machines might replace classroom teachers; others had great expectations for computers to standardize educational opportunity and achievement. However, the response of many school systems has consisted of including a course in computer programming to be taken after the completion of several mathematics courses. This results in attracting only students who are college bound or who have a high interest in mathematics and science courses. The implication of this is that only a few gain access to the skills needed to control the computer which continues to be a powerful influence on daily life in our society. The majority remain naive to its advantages and disadvantages. Results of this study will hopefully point out that computer programming is an area of appeal for <u>all</u> students, be they college or non-college bound, interested in arts and humanities or mathematics and science.

Furthermore, if this study provides evidence that right- <u>and</u> left-hemisphere modes of operation are equally related to achievement in, and favorable attitudes toward, computer programming, then there would be support for the fact that students, who ordinarily avoid highly analytic mathematics and science sources, might find an appealing outlet for their abilities via computer programming. The computer has the potential of being an artist's pallette or a musician's instrument as well as a mathematician's slide rule or a scientist's laboratory.

Definition of Terms

The following serve as operational definitions of terms used throughout the dissertation.

Computer Programming -- The process(es) of constructing an ordered sequence of formal statements in a programming language suitable for execution by a computer.

Right Mode of Cerebral Hemispheric Operation -- The use of holistic or pattern-seeking cognition, imagination, and metaphor to visualize and synthesize meaning.

Left Mode of Cerebral Hemispheric Operation -- The use of logic, language, and sequence to structure, order, and communicate information.

Integrated Mode of Cerebral Hemispheric Operation -- The use of both hemisphere's abilities, at one time or another, in responding to a specific task or situation.

Mode of Cerebral Hemispheric Operation -- Indicated by a student's scores on the self-report instrument, "Your Style of Learning and Thinking".

Limitations of the Study

This study is intended to be an initial investigation into a virtually untapped area. Consequently, it is exploratory in nature. The subject of inquiry is highly abstract in that the investigator will not have a concrete representation of students' brain functioning. Rather, students' self reports on a paper and pencil instrument are used to indicate mode of cerebral hemispheric operation. Thus, attempts to specify mode of cerebral hemispheric operation, or to make inferences about it, are limited by acceptance of the operationally defined constructs.

Making statements about an academic discipline based on the behaviors of a small group of students, enrolled in a specific course, at a particular time and place, also presents a challenge. This inhibits broad generalization, as does the fact that the investigator was the instructor of the course. A final constraint to be considered is the inability to control for all variables involved in the teaching/learning process. The group of Upward Bound students to whom the author taught an introductory computer programming class as part of a summer program comprised a highly specialized sample. They were influenced by many concerns and events that differed from those of an average high school class.

Given these limitations, the study represents a first endeavor to examine hemispheric specialization in relationship to the learning of computer programming. It is intended to provide an information base from which some researchers can draw and to which others can add.

Outline of the Remaining Chapters

This first chapter has introduced the topic of interest and has provided background and theory which motivated the author to address the relationship between hemispheric specialization and the learning of computer programming.

Chapter II includes a review of the literature relevant to the topic of study and will focus on three major areas: (1) research concerned with the documentation of hemispheric functions; (2) educational literature concerned with the need for, and current attempts in, addressing hemispheric functioning in the curriculum; and (3) research concerned with the teaching and learning of computer programming.

Chapters III and IV will describe and give results of the study conducted during the summer of 1977 at the University of Massachusetts with a group of Upward Bound students. The students were involved in a six-week course of instruction entitled, "Introduction to Computers and A Programming Language."

Chapter V provides a summary, conclusions, and suggestions for further research. Finally, included are a bibliography and appendices which contain course outline, modules, and handouts, instruments used for data collection, and supplementary tables.

CHAPTER II

REVIEW OF THE LITERATURE

Overview

Recent research findings concerning the human brain demonstrate that its two hemispheres function differently in significant ways. The abilities of each complement those of the other and, working together, they form a fully functioning consciousness. The nature of hemispheric specialization has been a topic of intensive study by biologists, psychologists, neurologists, and surgeons. Their discoveries result in important implications for education.

Another major influence on lifestyle and education in western society is the advent of the electronic digital computer. Accepted "normal" limits in such areas as travel, medicine, communication, and business transactions have become archaic due to its presence. Daily discoveries of more and more applications of the computer seem to make its power unlimited. Together, results of research in human intelligence and computer applications, have profound implications for change in living and learning in modern society. Carl Sagan (1977), in his work concerning the evolution of human intelligence, speculates "the next major structural development in human intelligence is likely to be a partnership between intelligent humans and intelligent machines" (p. 225).

This chapter includes a review of literature concerned with documentation of hemispheric specialization as well as that which describes several projects concerning the teaching and learning of computer programming. More specifically, split-brain research and its implications for viewing western culture and educational practices are discussed, along with selected instructional applications of computer projects which seem directly related to the development of right as well as left hemispheric abilities. This literature comprises the basis for the author's investigation into computer programming as an academic discipline which provides education for both sides of the brain.

Hemispheric Specialization

Split-Brain Research

Most literature concerned with the special cognitive functions of each cerebral hemisphere includes reference to the surgery performed at the California Institute of Technology by Roger Sperry, Joseph Bogen, and Michael Gazzaniga. The operations, performed on animals and later on persons suffering from epilepsy, involved severing the interconnecting fibers (corpus callosum) which join the two hemispheres of the brain. Results of the animal experiments demonstrated that cutting the corpus callosum did not impair brain functioning and encouraged the surgeons to perform the operation on humans to control epileptic seizures (Bogen, 1975; Gazzaniga, 1975; Ornstein, 1972; Pearce, 1974; Sagan, 1977; and Smith, 1975).

Generally speaking, the operation resulted in no major change, over time, in the patient's temperament, personality, or general intelligence (Gazzaniga, 1975). The seizures were isolated and these "split-brain" patients provided an excellent opportunity for research into the duality of mind concept. Many tests were devised to uncover evidence that the operation had clearly separated the specialized functions of the two hemispheres.

One tactile experiment involved the patient holding a pencil in the right hand (connected to the left hemisphere) at which time (s)he had no problem describing it, as would be normal. However, if the pencil was in the left hand, it could not be described since the left hand is connected to the right hemisphere which has no capability for speech. The patient could choose from a group of objects that which (s)he had held but still could not verbally describe what was happening (Gazzaniga, 1975).

Ornstein (1972) describes other experiments performed with the "split brain" patients. One involved visual input where the word "heart" was flashed to the patients with the "he" to the left of the eyes' fixation point and the "art" to the right. When the patient was asked to name the word, (s)he replied "art"; but when asked to point with the left hand to the word written on a card, the left hand pointed to "he". The verbal (left) hemisphere gave one answer and the non-verbal (right) another.

Another experiment showed that the right hand could write English words but could not draw very well. It seemed to have lost its ability to work in a relational, spatial manner. The left hand could draw and copy figures but could not copy a written word. Such tests became initial confirmations of isolated hemispheric functions.

It may be questioned how valid it is to generalize from surgical cases to a population whose corpus callosums remain intact. To address this, Ornstein and Galin at the Langley Porter Neuropsychiatric Institute, and numerous other researchers working independently, have performed experiments to confirm neurological explorations, with persons having intact corpus callosums. Most of the experiments reported fall in three categories: (1) in carefully controlled and complex clinical environments, visual or auditory stimuli are presented to each hemisphere and reactions are observed and timed; (2) an electroencephalograph is used to record brain waves during different kinds of mental activities--higher alpha rhythms denote a turning off of the hemisphere; and (3) direction of eye gaze is noted during different cognitive tasks--in almost all right handers and in many left-handers, gazing right indicates the left hemisphere is functioning and gazing left denotes right hemisphere activity (Bogen, 1973; Buck, 1976; Brown, 1975; Gazzaniga, 1975; Kinsbourne, 1974, 1972; Krashen, 1975; Kumar, 1973; and Nebes, 1975).

Results of Split-Brain Research: An Interpretation of the Functions of Each Cerebral Hemisphere

Sage (1976) summarizes results of experiments documenting hemispheric specialization in stating that the left hemisphere takes in information bit by bit, processes it in linear, logical fashion and carries on verbal and mathematical reasoning. It is verbal and communicates with the outside world through language. The right hemisphere, however, does not speak; it perceives images holistically in gestalts. It is the base for abstract thinking and processes information spatially and intuitively. It is the locus for creative and artistic abilities and appreciation of forms and music.

The language, analytic, linear-processing, and temporal-ordering abilities of the left hemisphere are described by Stephen Krashen (1975). He explains that knowledge of the left hemisphere's involvement with language stems from several facts. First, loss of speech caused by left-hemisphere damage is far more frequent than that caused by right. Secondly, loss of speech results when the left hemisphere is temporarily anesthesized but does not generally result when the right is anesthesized. Verbal material presented directly to the left hemisphere results in superior accuracy and response time. And, finally, during verbal tasks the left hemisphere showed less alpha.

All aspects of language, however, are not limited to the left hemisphere. Buck (1976) reports that the right hemisphere can use some words at their face value. Zaidel (cited in Bogen, 1975) indicates that the right hemisphere also possesses some syntactic capability but that it is insufficient for constructing complicated sentences. Hemispheric specialization seems to begin at about age five. According to current linguistic theory, the development of adult language also begins around age five (Krashen, 1975). Thus, Kashen hypothesizes, the temporal-ordering abilities of the left hemisphere may be influential in its becoming dominant for language.

These abilities facilitate the programming of an idea into a sequence of linguistic units, an essential process in adult language.

In addition to the left hemisphere's language ability, Krashen also reports on the non-verbal processing that occurs there. Most of these non-verbal functions are time-related and involved analytic processing.

The left hemisphere's complement--the right or "minor" hemisphere--is specifically described by Nebes (1975). He explains that for most of the preceding century, the focus of scientific attention was on the left hemisphere because of its unique language ability and was consequently termed "major." In fact, all higher mental functions were believed to be carried on or supervised by the left hemisphere. However, recent research results indicate that the right hemisphere is dominant in the recognition of faces, patterns of stimuli, and complex shapes, as well as musical melodies and chords. In other words, the right hemisphere is superior to the left in processing non-verbal material.

Nebes also explains that the right hemisphere is more interested in the inter-relationships of the part of a stimulus to the whole--it possesses a holistic bias. It is superior to the left at constructing, from partial sensory information, a concept of the total stimulus. This was evidenced by subjects' ability to estimate, from a small piece of an arc, the size of the complete circle of which it was a part, or to visualize the complet contour of a shape from examination of its scattered fragments. Timing visual search tasks in which subjects were asked to determine whether all letters in an array were the same also confirmed the right hemisphere's method of pattern-seeking or holistic processing. The faster time of the right hemisphere seems to have to do with the different ways of treating language material--verbally for the left and visual-spatially for the right.

Nebes concludes that the right side of the brain processes information differently from the left, relying more on imagery than on language, being more synthetic and holistic than analytical and sequential in handling data. It is important in perceiving spatial relationships and in making conceptual sense of fragmented sensory input, thereby providing a cognitive spatial map by which individuals plan their actions.

Finally, Nebes purports that the mystical and humanistic aspects of civilization are products of the right hemisphere whereas the left produces scientific and technological aspects. Commenting on this connotation of the right hemisphere, Ornstein (1973) explains that since western technological society devalues mysticism, this hemisphere is termed "minor." Sagan (1977) contends that western society's awareness of right hemisphere functions is like the ability to see stars in the daytime--the brilliance of the verbal abilities of the left hemisphere obscure the awareness of the intuitive abilities of the right.

In summary, the human brain consists of two hemispheres, each with a separate mode of thinking and knowing. One mode, that descriptive of the left hemisphere, is articulate, verbal-intellectual, involves reason, language, analysis, and sequence. The other, illustrative of the right hemisphere, is tacit, sensuous, and spatial; it operates in a holistic, relational manner (Ornstein, 1973).

Implications for Western Culture and Education

In response to the research findings concerning the specialized functions of the two cerebral hemispheres, several scholars have indicated that western society is exclusively oriented to left-hemisphere functioning. Deikman (1973) maintains that the dominant mode of a culture is directly reflected in its every activity as well as in its social and political organization. He defines two modes--one of "action" and one of "reception"--the choice of which is defined by the motive of a culture. The action mode denotes a state organized to manipulate and structure (left-hemisphere functions) the environment, a state of striving toward achieving personal goals. He suggests that this mode reflects the orientation of western civilization which is toward exerting direct, voluntary control over all phases of life. This is evidenced by the acclaim given to the ideal of the "self-made" man and by the pursuit of the material and social goals. This action mode, which requires the manipulation of environment and self, "dominates western consciousness" (p. 71).

Deikman's alternative "receptive" mode denotes intake of the environment. He suggests that as the material success of a culture eases the task of survival, a secure basis is provided for developing the receptive mode of consciousness as the dominant one. Such a position implies that the experiencing, feeling abilities of the right hemisphere might indicate more, rather than less, advancement of a culture.

Ornstein (1972) points out that a counter-culture, opposed to science and technology, is emerging in contemporary western society and focuses on a mode of knowing which is arational, non-linear, and personal in nature. This culture is interested in developing conscious capacities beyond currently defined "normal" limits. Smith (1977, p. 64) indicates that "excellence in one hemisphere tends to interfere with top-level performance in the other" such that it is unfortunate that "superrational lawyers and great mathematicians make lousy dancers." Konicek (1975) suggests that this either left or right orientation need not be the case. He proposes a concept of "synergy" for the two-hemisphere brain which results in the output of two minds being greater than the sum of the two halves. He continues to explain that "if individuals are encouraged to extend themselves, there would seem to be an unlimited potential for educating both sides of the human mind" (p. 38). He challenges education to provide learning environments that allow the right hemisphere to be heard and develop its potential.

Piaget, whose theory of cognitive development has recently regained the attention of educators, also stresses the importance of providing an active learning environment in which the child has many opportunities for experiencing. This, according to his theory, is important so that the child can adapt his/her cognitive structure to the environment through "assimilation" and "accommodation" (Wadsworth, 1971). An active learning environment is especially essential for the period of concrete operational thinking which occurs during the early years of schooling. Wheatley (1978) indicates that studies show the right hemisphere to be dominant in most children whose interactions with the environment are visual-spatial whereas the left is more active in most educated adults who operate at the formal operational level. He suggests that educational programs that focus on opportunities for exploration, non-verbal expression, and multi-sensory learning may enable students to reach new levels of performance which involve using both left brain abilities (involved in formal operational thought) <u>and</u> right brain abilities (involved in concrete operational thought). Such an approach might preclude the left hemisphere's becoming the dominant focus of western schools.

Several other authors support the need for education in western society to cultivate the visual-spatial, intuitive skills of the right hemisphere to the same extent as the verbal, rational, analytic ones of the left. Hunter (1976) accuses schools of beaming most instruction through a left-hemisphere input (reading and listening) and output (talking and writing) system which handicaps all learners. She mandates the responsibility for presenting information in such a way that students can practice integrating it from both hemispheres. Bogen (1975) makes this same point by suggesting that education in American schools be designed to stimulate the development of brain processes in addition to the verbal and analytic ones commonly emphasized. He supports Sperry (1973) in the fact that modern society discriminates against the right hemisphere and encourages schools to allow students to be as they are becoming. Nebes (1975) summarizes these positions by explaining that we may be shortchanging ourselves if we educate only talents of the left hemisphere in basic schooling.

The fact that schools place almost exclusive emphasis on left hemisphere functions has profound implications for a different view of the "disadvantaged" learner. Rennels (1976) reports an example of a sixteen-year-old student who could not read but showed superior visual and spatial abilities. He suggests that the school was apparently unable to assist the student in merging the two cerebral functions. Rennels also points out that schools systematically eliminate experiences that assist young children's development of visualization, imagination, and/or sensory-perceptual abilities. Beginning in preschool and kindergarten classes, the child is encouraged to delete sensory-imaginative behaviors in favor of verbal-numerical skills. They are asked to sit quietly and absorb the input of linear data. Johnson (1977) and Samples (1975a) both report high degrees of success for inner city youth participating in science activities designed to tap the abilities of the right hemisphere. Samples explains that "even though the kids couldn't read or do math, they were bright people . . . with highly refined and mature intuitive powers . . . which their teachers chose to ignore" (p. 23). It is common knowledge that Einstein himself exhibited a disability in the verbal realm (Patten, undated) and yet his ability to manipulate mentally visualized images provided relativity theory.

Several alternative models of thinking have been proposed for developing right cerebral abilities. Austin (1974) discusses scientific discoveries that have happened by "chance" and outlines four levels of chance. He defines the highest level as "a facility for encountering unexpected good luck as the result of highly individualized action favored by distinctive, if not eccentric, hobbies, personal life-styles, and mode of behavior peculiar to one individual, usually invested with some passion" (p. 62). This encounter with scientific discovery is quite different from the view that it is a purely rational endeavor.

In contrast to Piaget's theory of learning as a logical, linear process which leads toward formal operational thought and is reached by learning to limit the possibility to the narrowest in order to solve a problem, J. W. Gordon proposes "metaphoric knowing." This model, interpreted by Samples (1975b) and discussed by Konicek (1976), involves a non-hierarchical interactive process between comparative, symbolic, inventive, and integrative thinking.

"Lateral thinking," proposed by deBono (1970), is another example which contrasts the logical, sequential thinking which is, by tradition, the only proper use of information. An underlying premise of this model is that it may sometimes be necessary to be wrong in order to dislocate a pattern sufficiently for it to re-form in a new way. The main purpose of lateral thinking is to provide a means to restructure patterns. The restructuring of patterns is necessary in order to make better use of information that is already available. Lateral thinking is directly concerned with insight and creativity and is complementary to logical thinking as it acknowledges the extreme usefulness of order and pattern.

Finally, W. C. Wittrock (1977) discusses a "generative process" of memory which involves the imaginative skills of the right hemisphere. In experiments with learning tasks concerned with vocabulary definition, he found that recall was greatest when the learner related new information to his/her experience and was required to construct associations or meanings. This involved both verbal and imaginative reasoning abilities. Wittrock suggests that the art of teaching "needs to devise sophisticated ways to facilitate the multiple processing systems of the brain" (p. 177).

Several specific teaching methods for actualizing right hemisphere skills are outlined by various authors. Samples (1975a) encouraged teachers to allow students to "get to know" a science problem through informal, playful, fantasy, and sensory exploration before snapping them into a left mode of thinking with direct questions. Wheatley (1977) discussed this same approach to problem solving in mathematics, suggesting that puzzles, open-ended tasks, and a laboratory approach provides students the opportunity to develop skills in imagery. Bybee (1972) reminded teachers of the 1970 White House Conference on Children which recommended that all children have opportunities to learn, grow, and live creatively. He suggests that creative science activities involve the child coming to a solution by freely exploring problems with fluency, flexibility, originality, and insight. In teaching earth science to college freshmen, Johnson (1976) used art, music, metaphor, fantasy, and body movement to enhance concepts.

In disciplines other than science or mathematics, recommendations have been made to encourage creative, original thinking through stimulating an interplay of the modalities of the mind (Pearce, 1974). Ornstein (1973) suggests that the "Sufi" stories enable students to see the improbable, the unusual, the "paranormal." Such experiences help westernized individuals to absorb experience through the non-sequential mode and make their intuitive capacities greater. Finally, Doktor (1974) has suggested that certain areas of computer assisted instruction (CAI) develop right as well as left hemisphere abilities. A review of this area follows.

The Teaching and Learning of Computer Programming

As mentioned in Chapter I, a great deal of the literature concerning instructional applications of computers addresses their use as "teaching machines." This use is not relevant to a discussion of the ways in which computers can facilitate the visual/spatial/intuitive/holistic abilities of the right hemisphere along with the logical/analytical/verbal/linear skills of the left. Literature and specific computer projects selected for review, therefore, are directly concerned with students controlling the computer via programming and using it for their own problem-solving attempts and intellectual development.

The underlying motivation for the author's investigation was a paper presented by Robert Doktor at the Tenth Annual EDUCOM Conference in which he questioned the possible relationship between the teaching and learning of computer programming and right as well as left modes of information processing. He suggested that "it may well be that in teaching programming we are developing right as well as left hemisphere abilities" (Doktor, 1974, p. 12). He reminded educators that the simulation mode of computer assisted instruction provides excellent opportunities for developing the "combination play" abilities of the right hemisphere in student programmers. He also suggests that educators guard against raising the logical analysis on a pedestal over the intuitive synthetic and encourage the integration of the two modes of cognitive style.

Several educators have specified what it is about the computer, as an instructional tool, that fosters this integration of right and left cognitive abilities. Denenberg (1977) explains that the computer is a special kind of machine:

> It can be understood as a 'universal machine' in that it can simulate most any other machine. It can be an airplane flight simulator, a rapid transit system or rocket ship. It can also simulate organic systems ranging from a single cell to a society of people. It affords insights. It is a media/medium in itself such that it can draw, animate, paint, compose and play music (p. 51).

Such a testimony indicated how programming can provide an <u>active</u> learning environment in which the student is able to create inexpensive, responsive models.

The development of a full conscious potential mandates that the student be more than a passive receptor of verbal input. Elliott (1973) indicated that "if learning is to truly beget more learning, the learner must be given control over his/her environment as well as concomitant responsibility for his/her learning" (p. 15). She proposed that educational technology has tremendous value in that it gives the student control over physical phenomena in a laboratory setting and, more importantly, control over their own intellectual inquiries. Elliott alluded to the combined use of analytic and intuitive cognitive modes by pointing out that ". . . using the computer as an objective reflector of our own understandings can maximize the spur-of-the-moment revelations ('aha' experiences) and minimize confusion resulting from illogically presented materials" (p. 11).

This "computer as pupil" concept was the central focus of the Dartmouth Secondary School Project. Kurtz (1970), in the project's final report, also reflected the interplay of analytic and holistic cognitive abilities:

> Because we had to teach an ignorant machine, we were forced to break the process down into pieces, arrange these pieces into proper order, and present them to our pupil machine. . . . Before we made an effort to teach this 'pupil,' we were forced to clearly understand the problems ourselves (p. 18).

This project considered the computer to be invaluable as it provided a new and excellent way to teach the art of problem solving by giving students the responsibility of teaching various tasks to machines via programming.

Luehrmann (1972) illustrated the power of the computer as an educational tool by explaining that it could be programmed to simulate the instructional process. Given the potency of this resource, he insists that students should be taught to program so that they may become "masters of computing, not merely its subjects" (p. 410). In an article concerning whether the computer should teach the student or vice versa, Luehrmann states:

> A student, programming a problem, and debugging it, is in a totally different mode of intellectual activity than another who is subject to lecturing or a CAI lesson. When instructing the computer, a student is directing his own inquiry into the subject under study. He is the master, not merely the end product of some cost-effective new technology (p. 10).

Finally, Minsky (1973), heralding the inclusion of student-controlled CAI in schools, insists:

> Once the powerful concepts inherent in programming are elucidated and internalized by educators, American education may be radically changed. . . . Eventually, programming itself will become more important than mathematics in early education (p. 48).

This notion of students controlling computers and thereby their own learning and intellectual development has been viewed as threatening to many educators who fear the "machine-monster" and envision a take-over of society by computers. However, there are several projects which have implemented the student-controlled CAI and are available as models of the dynamic "humaneness" involved in this concept. One which should clearly relieve the anxiety of those who fear being replaced by computers in the classroom is Project Solo, at the University of Pittsburgh. The project is based in a large urban environment and is guided by five humane principles. These include:

(1) Innovation will work if it develops skills which the learner perceives as gaining him recognition;

(2) there must be a well-developed supporting structure, including teachers, curriculum, and an educational theory, available to accompany a hardcore system;

(3) continual attention must be given to the tapping of internal resources that every learner brings to the learning situation;

(4) educators must be wary of the 'logical' sequence of fixing objectives first, then developing a curriculum to match, without regard to the population or the potential for improvement; and

(5) the intrinsic fun of real computing must be preserved at all costs (Dwyer, 1971).

Students, participating in the Solo project, begin in the "dual mode" where they share control with already written computer programs. The ultimate goal of the project is to guide them to the "solo" mode where they write their own programs for problem solution. Another major objective is to stimulate students to synthesize and organize knowledge on their own, using algorithmic problem-solving and student-controlled computing as catalysts. "Solo mode" learning is the process of acquiring knowledge, skills, and insights through an interaction between the learner and a set of subject-oriented experiences. Dwyer maintains that "meaningful educational innovation over the next few decades is very much dependent on the intelligent communication between the humanist and the technologist" (p. 220).

Another project that exemplifies the exciting opportunities which the computer offers for teaching concepts and techniques in problem solving, and which encourages the child to become an intellectual agent in the problem solving process, is Seymour Papert's LOGO, at the Massachusetts Institute of Technology. LOGO's philosophy is that children learn best by doing and by thinking about what they do. It uses computer controlled devices such as a mechanical "turtle" which students manipulate via simple programming. Students become creatively involved in exploring the possibilities of the devices and learning is natural and effective (Papert, 1972a). Project LOGO does not use technology in the form of machines for processing children, but "as something the child himself will learn to manipulate, to extend, to apply to projects, thereby gaining a greater and more articulate mastery of the world, a sense of the power of applied knowledge and a self-confidently realistic image of himself as an intellectual agent" (Papert, 1972a, p. 1). Papert (1972b) elucidated the dynamic philosophy of the LOGO project:

> The job of children at school is learning, thinking, understanding, playing and we want to teach them about learning, understanding, and playing, but we don't. We teach them about numbers, grammar, or the French Revolution. . . . Computer science has a dramatic impact on the world of education by doing this. . . . Having the child program a computer is good--he is deeply active and using his knowledge to get results (p. 19).

A concluding example of an approach to computer assisted instruction that seeks to give the student control over his/her own learning and encourages the development of a fully functioning consciousness is the "Glass Box" approach, initiated by Howard Peelle at the University of Massachusetts. This approach provides short, comprehensible computer programs for students to view directly. Each program embodies a concept or procedure and is written as simply and clearly as possible such that the inner workings of the program are visible and, hence, become the basis for learning. After an initial period of examining, analyzing, predicting, and experimenting (an interplay of right and left cognitive abilities) with a glass box program, students are encouraged to modify, extend, and create glass boxes of their own.

"Glass box" programs are in contrast to traditional "black box" ones which mask the step-by-step goings-on of a program, as well as prevent a view of the inter-relatedness of each line which make up the entire concept. Specific characteristics of a "glass box" program are:

Simplicity -- A single idea of modest scope is taught using a brief program;

Comprehensibility -- Clear, readable commands with well-chosen mnemonic identifiers are used for program variables;

Flexibility -- The program is designed for easy modification and can be used with other programs in modularized structures;

Generality -- The program uses mathematical models which extend to a class of cases;

Elegance -- Expressions are used that "strike aesthetic chords"; and

Provocativeness -- The program's implications suggest interesting follow-up discussions.

Given these characteristics, the "glass box" program can be viewed as a "pedagogical agent which fosters insight and learning" (Peelle, 1974b, p. 9). Peelle, in presenting this approach to students and teachers, stresses A Programming Language (APL). This language has been hailed for its concise notation, generalizability to arrays, and for making it easier to appreciate patterns and structure in mathematics. Hence, APL seems particularly appropriate for complementing the underlying philosophy of the "Glass Box" approach to computer programming.

In all the aforementioned projects and approaches to educational uses of the computer, the focus was on students controlling, rather than being-controlled-by, machines. Such a focus provides students with the opportunity to use the computer as a tool for developing their full conscious potential.

Summary

This chapter has included a review of literature which formed the foundation for the topic under investigation which concerns whether computer programming can be viewed as an academic discipline which provides education for both sides of the brain. First of all, research documenting the existence of specific functions of each cerebral hemisphere was presented. The findings reviewed included experiments with both "split-brain" and "normal" individuals. Secondly, suggestions of several authors concerning the implications of this brain research for western culture and education were provided. Thirdly, specific teaching methods and educational procedures based on the notion of specialized cognitive functions were reviewed. Finally, literature concerning selected instructional applications of computers projects which were projected as encouraging the development of both right- and left-hemisphere abilities was presented.

There is, therefore, a substantial body of literature which supports this exploratory study. The following chapter describes the exploratory research which the author conducted at the University of Massachusetts in the summer of 1977.

CHAPTER III

METHODOLOGY

Introduction

Chapter I established the need for schools to provide more opportunities for students to actualize the imaginative, spatial, and holistic skills of the right hemisphere. It suggested that computer programming might be an area in the curriculum which yields such opportunities. Chapter II included a review of literature concerned with hemispheric specialization, how it pertains to schools, and research having to do with the teaching and learning of computer programming.

This chapter will outline the exploratory research conducted by the investigator at the University of Massachusetts during the summer of 1977. The design of the study, the participants, the instruments used and procedures followed for data collection and analysis are described. Also included is an overview of the six-week computer programming course during which data were collected.

The Study: Introductory Considerations

As previously stated, the general intent of this investigation is to find if there is support for the fact that "computer programming is an academic discipline which provides education for both sides of the brain." In other words, does computer programming offer students an opportunity to use both analytical/logical cognitive abilities as well as intuitive/holistic abilities? To investigate the topic, data were collected during the summer of 1977 at the Amherst campus of the University of Massachusetts. Seniors and "bridge" (high school graduates who plan to attend college in the fall of 1977) students from Upward Bound, an academic enrichment program, participated in a six-week course entitled "Introduction to Computers and A Programming Language." The investigator, who instructed the course, collected data at this time.

The feasibility of making statements about a discipline by observing, recording, and measuring student behaviors might seem questionable. However, a review of educational research indicates that others have approached similar problems in this way. For example, Kenneth Goodman, in establishing inferences about the reading process (discipline), developed a taxonomy for analysis of readers' behaviors, or "miscues." Subsequent to analysis of the readers' behaviors, a theory concerning the reading process was developed (Goodman, 1969). Robert Samples, mentioned earlier, in reports of his work with the Elementary Science Study, also made inferences about science activities based on the behaviors of students (Samples, 1975B). A more global example is the use of behavioral objectives in education in which decisions about the worth of a discipline are based on measuring students' behaviors.

In taking this approach to measuring the academic discipline of computer programming, the investigator makes inferences about the hypothesis that computer programming provides education for both sides of the brain by observing, recording, and measuring student programmers' behaviors.

Prior to outlining the specific design of the study, it is necessary to present an additional assumption on which this exploratory research is based. It was pointed out in chapters one and two that most individuals use both their right and left hemisphere and do so with no conscious effort. Therefore, at any given amount of time, an individual may be utilizing his/her right <u>or</u> left hemisphere but, over time, would use <u>both</u> hemispheres even though based on training and experience, he/she might use one hemisphere more often than the other. Since all normally functioning persons use both hemispheres, categorizing individuals as "right" or "left" would exclude their use of the opposite hemisphere. Even considering individuals as right or left-dominant would enter into an argument of "how dominant" and would still exclude vital information, especially in looking at a small group of people. Consequently in the design of this study, the investigator has taken into account the participants' self reports of relative use of the modes of operations of both hemispheres. It should be noted that each participant has one assessment of attitude, achievement, and self concept, but three measures for hemispheric orientation--one for relative use over time of the right hemisphere, one for the left, and one for integrated which indicates exclusive use of neither right nor left.

Design

In gathering data for this exploratory study, the investigator considered students' self reports of relative use of right and left hemispheres, assessments of their attitudes toward, and achievement in, computer programming, and measures of academic self concept. In addition, the investigator asked students for self reports of their programming behaviors.

This research is considered "exploratory" since no particular set of responses is known or predicted in advance. Rather, the study is conducted to see if there is support for the general hypothesis that computer programming is an academic discipline in which all students have an opportunity to actualize both intuitive/global and logical/analytical skills.

The one-group pretest-posttest exploratory study also can be considered "correlational" in that it investigates the extent to which variations in modes of hemispheric operation correspond with variations in the achievement, attitudes, and academic self concepts of student computer programmers.

Lastly, the study is "descriptive" in that it attempts to identify specific behaviors during various aspects of the programming process which correspond to intuitive/global or logical/analytical modes of hemispheric operation.

This design is intended to provide a structure for answering the following questions:

(1) Is there a relationship between mode of cerebral hemispheric operation and achievement in computer programming?

(2) Is there a relationship between mode of cerebral hemispheric operation and attitude toward computer programming?

(3) Is there a relationship between mode of cerebral hemispheric operation and academic self concept (in student computer programmers)?

(4) Is there a relationship between mode of cerebral hemispheric operation and specific aspects of the computer programming process?

Sample

In the spring of 1977, the director of the University of Massachusetts, Amherst, Upward Bound Program was contacted in order to ascertain the feasibility of including an introductory computer programming course among the program's summer academic offerings. Upward Bound is an academic enrichment program for high school students who have been identified as potentially successful in college but for various reasons (e.g., financial, motivational) would probably not attend college without the program's support. Students usually enter the program during their sophomore or junior year. They are assigned to an Upward Bound counselor who advises them during the academic year and structures support seminars and activities. Each summer they have the opportunity to participate in a six-week program offered at a local college or university. They live in dormitories and take part in academic, social, and cultural activities. Students take a variety of courses, ranging from the usual high-school offerings (e.g., English, algebra, American history) to special interest offerings (e.g., African history, journalism, English as a second language). Students who had been unsuccessful during the academic year in required courses have the opportunity to earn credit toward graduation by successfully completing those courses in the summer. In addition to this remedial arrangement, students may elect courses from the variety of special interest offerings. Upward Bound instructors are certified secondary teachers, representing all major disciplines.

The investigator's course, Introduction to Computers and A Programming Language, was included as a special-interest elective and was open to seniors and bridge students. Of the seven Upward Bound bridge students, four enrolled in the course; eight out of fifteen seniors enrolled. Two of the twelve (one bridge and one senior) enrolled did not complete the course and were eliminated from the investigation. (Both left the program after the third week.) There were seven black participants, two Hispanic, and one white. Four participants were female and six male. One student had completed four years of mathematics in high school, the most advanced course being Algebra III. Four had taken Algebra I, Geometry, and Algebra II. Of the remaining five, all had taken General Mathematics and two of those had taken General Mathematics II.

The sample seemed particularly appropriate for the topic under consideration since the investigator's intent was to discover whether computer programming offered learning opportunities for all types of students, not only those having a prior high interest and ability in mathematics.

The sample of ten students was fairly well distributed in scores on the instrument concerned with hemispheric orientation. The group scores, means and standard deviations are reported in Table 1, Chapter IV. Norms for the instrument, "Your Style of Learning and Thinking," are based on its administration to fifty beginning college students at the University of Georgia; all students were white and 75% were female (Reynolds, 1977). The left hemisphere orientation scores of students in this study were slightly higher than the norm, however the integrated scores were slightly lower. Those of the right are essentially the same as the norm. The sample means and standard deviations, rather than those of the norm, are used in the data analysis of this study.

Course Description

"Introduction to Computers and A Programming Language" was designed to offer participants basic information concerning the applications and limitations of computers in our society. It was also intended to provide an initial experience in programming a computer. It was not intended to be a comprehensive academic offering but rather an introduction to a learning experience in which Upward Bound students had not had the opportunity to participate. As such, the course was intended to give students access to the computer, a virtual "unknown" in urban schools. Students were expected to be quite familiar with the "being-controlled-by" end of computers but not to have had previous experience with the "controlling" end. Additionally, the course was designed to provide students with motivation to pursue the discipline in greater depth at the college level as the course exposed a field in which there are countless career possibilities.

Specifically, the six-week summer offering, designed and instructed by the investigator, was intended to:

(1) provide basic knowledge of computers, how they operate and some of their applications and limitations;

(2) provide introductory skills in the use of A Programming Language (APL) for the purpose of interacting with the computer and beginning to use it as a tool in learning;

(3) foster positive, unintimidated attitudes towards computers as machines that humans can control and use to benefit society; and,

(4) foster increased academic self concepts resulting from successful and enjoyable computer programming experiences.

The course was offered three days each week for one and a half hours and continued for six weeks. Formal presentations and lectures working in the interactive computing mode. The language was conceived by Kenneth Iverson and has been recognized for facilitating the application of patterns and structure in mathematics (Berry, 1973). It is a high-powered and exciting language whose notation is quite distinct and mathematical in nature. Its rules for syntax are consistent and it is able to accommodate a broad range of programming problems and student abilities.

Curriculum

To provide an organizational framework for the study, the instructor devised five modules: (1) "Getting Familiar," (2) "Gaining Control," (3) "Elements of Communication," (4) "Further Interaction," and (4) "Putting It All Together." At the beginning of each module, students were given a handout which included a summary of the module, learning objectives, and activities in which they would participate. The course outline and module handouts are included in Appendix A.

Content and materials used in the course were adapted from Howard A. Peelle's "U-Programs" (Peelle, 1974a) and "Mini U-Programs" (Peelle, 1972) and from Portia Elliott's "APL for Teacher-Learners" (Elliott, 1973). Course materials are presented in Appendix B.

As previously mentioned, the course was not intended to be a comprehensive academic offering. Rather, it was designed to "whet the appetite" of students. Consequently, with the end goal of students' programming the computer in mind, a variety of methods were used to establish a rapid pace at the beginning of the course. Films, a tour of the University Computing Center, and pre-stored computer games were

Mode of Cerebral Hemispheric Operation

The investigator selected the instrument, "Your Style of Learning and Thinking," to obtain scores designating participants' relative use of the right, left, or integrated mode of hemispheric operation. The instrument was chosen over other paper and pencil assessments because, unlike those concerned with cognitive style, general intelligence, or creativity, this self-report survey was designed specifically to measure the relative psychological dependence of an individual on the right or left hemisphere of the brain (Reynolds, 1977). Consequently, this instrument was most relevant to the topic of study.

The instrument is based on current research findings concerning the functions of the two hemispheres of the brain. It includes questions on right and left hemisphere functioning as well as the integrative capacity of the two hemispheres. There are two forms of the instrument, a college/adult form developed by Torrance in 1975 and a high school edition adapted from the college version by Riegel and Reynolds in 1976. The high school form was used in this study.

Validity of the instrument is based on the content of the items (drawn from the literature concerned with cerebral hemispheric functioning) and correlations between the three scores yielded by the inventory (right-brain, left-brain, and integrative functioning) and various measures of personality, emotional sensitivity, and creativity. The authors report that test-retest studies typically yielded reliability coefficients in the .80's (Reynolds, 1977).

As previously mentioned, "Your Style of Learning and Thinking" is a self-report survey. The investigator is aware that self-report techniques have many potential flaws, however this technique seemed most feasible for obtaining information about participants' use, over time, of the right and left hemispheres. It was believed that individuals themselves had the most information about how they usually perceive or perform in a certain situation. In addition, the non-threatening nature of the items seemed to call for honest responses. The instrument was very easy to administer to the entire group under study and required no specialized psychometric skills.

The instrument contains forty items, each providing the respondent three choices--one representing a specialized function of the left hemisphere, a second representing a parallel specialized function of the right hemisphere, and a third representing an integration of right and left hemisphere functions. Participants in the study were asked to indicate which of the three specific styles of thinking and/or learning best described their own typical behavior. Responses were tallied for each participant and three scores were obtained--"R" indicating relative use over time of the right hemisphere, "L" indicating that for the left, and "I" indicating integration of right and left hemisphere functions. R, L, and I for each person totals forty. Table 1 presents the scores for the group studied.

Prior to the study, permission was obtained from the authors for including their instrument in this study.

Attitude Toward Computers

"An Opinion Survey: How Do You Feel About Computers?" was constructed by the investigator to survey participants' attitudes towards computers and computer programming. The content of items on this instrument was adapted from other computer-opinion surveys, but the style of presentation was intended to maximally personalize the instrument for students in this study. Items were designed to assess attitudes in three areas: (1) need for general knowledge about computers--Items 1, 8, 13, 16, 17 and 20; (2) social applications of computers--Items 2, 5, 6, 10, 14, 18 and 19; and (3) personal skills in computer programming--Items 3, 4, 7, 9, 11, 12 and 15.

At the time of construction, input regarding validity of the items was solicited from both content and psychometric specialists. The instrument in its final form was administered prior to the study to an undergraduate Computer Literacy class and to three classes of high school students. Using a split-half method for checking reliability, in which responses to half the items assessing each area were correlated with those from the other half, the correlation coefficients for the various administrations of the instrument ranged from .78 to .92.

Participants were asked to choose from the responses, "strongly agree," "agree," "unsure," "disagree," and "strongly disagree," that response which indicated the degree to which they agreed or disagreed with each statement. The most positive response was given a score of five, the next most positive four, etc. Each participant's total score was divided by the total number of items (20) such that final scores could range between one and five, five indicating the most positive response was given to every item and one the most negative.

Academic Self Concept

After an extensive review of group-administered self-concept instruments, the "Michigan State General Self Concept of Ability Scale" was selected to assess students' academic self concept for this study. The scale was developed by Wilbur Brookover in 1962 and remains one of the few scales that is directed specifically to self concept of ability. Dr. Brookover has used, and continues to use, this instrument in his studies concerning self concept and reports high validity and reliability for the scale. The investigator obtained his permission to use the instrument in this study.

This assessment of academic self concept contains eight items, each having five possible responses. Participants were asked to circle the response which best described their reaction to each statement. Scores were obtained by attributing five to the most positive response, four to the next most positive, etc. The total score was divided by the total number of items (eight) resulting in final scores ranging between one, indicating a most negative academic self concept, and five, indicating a most positive academic self concept.

Computer Programming Achievement

"APL Assessment" was the instrument constructed by the investigator to appraise participants' knowledge of APL and competence in using APL to program a computer. The instrument was adapted from an

APL achievement test used in a previous study at the University of Massachusetts (Elliott, 1973).

The computer programming achievement test assessed four areas: (1) function definition, (2) program modification, (3) program examination, and (4) program definition. The instrument included sixteen items for function definition (Items 1-16), worth two points each on the final score. There was one program for students to modify (Item 17) and one to examine (Item 18) or interpret. Each of these exercises was worth three points on the final score. Finally, students were asked to define (write) a program (Item 19). Five points were allotted for this activity. The total score possible on the instrument was forty-three.

Computer Programming Behaviors Checklist

"Programming Style" was designed by the investigator in an attempt to identify behavior of different participants during the various aspects of the computer programming process. Specific steps in the computer programming process for which items were written are:

-- problem identification,

-- problem understanding,

-- problem analysis,

-- program organization,

-- program construction/coding,

-- run analysis, and

-- debugging.

The instrument was developed as a self-report checklist since it was assumed that programmers themselves are best able to select from a choice of statements, that one which most closely identifies their behavior. In an attempt to avoid "locked-in" responses and to elicit as much information as possible, an "Other: Please Explain" choice was proviced for each item.

This instrument was constructed specifically for this exploratory study; therefore, some information concerning its validity will result from the study. Reliability will not be considered in the initial administration. At this point, content validity is based on literature concerning specialized functions of the cerebral hemispheres and the opinion of experts asked to "rate" each item on its appropriateness in identifying programming behaviors which are logical/analytical, global/intuitive, or both.

Data Collection and Proposed Analysis

Procedure

As part of the initial class meeting, students were asked to complete the following instruments: (1) "Your Style of Learning and Thinking," (2) "An Opinion Survey: How Do You Feel About Computers?" and (3) "The Michigan State General Self Concept of Ability." Students were asked to use "codes" rather than their names in order to assure anonymity. This procedure was intended to encourage honesty of response from students and objectiveness in analysis from the investigator.

The post-course instruments are administered as part of the final class session. They included: (1) "An Opinion Survey: How Do You Feel About Computers?" (2) "The Michigan State General Self Concept of Ability," (3) "APL Assessment," and (4) "Programming Style." Students were asked to use the same codes as they had on the pre-course instruments.

The investigator also gathered anecdotal data based on the types of programs students chose to write, printouts of students' work sessions at the terminals, and notes from a log kept over the six-week period.

Proposed Analysis

There was one set of independent measures obtained for each student from the instrument, "Your Style of Learning and Thinking." Included were scores indicating relative use of the right hemisphere, relative use of the left, and exclusive use of neither. The dependent variables were achievement in computer programming, indicated by scores from "APL Assessment"; attitude toward computers, assessed pre- and post-course by "An Opinion Survey"; academic self concept, assessed pre- and post-course by "The Michigan State General Self Concept of Ability Scale"; and computer programming style from "Programming Style."

As suggested earlier, this exploratory study can be considered "correlational" in that the investigator wished to look at relationships of variations in the independent variable--mode of hemispheric operation--with variations in the dependent variables--achievement in, and attitude toward, computer programming, and academic self concept.

In order to facilitate the correlation, the Pearson product-moment correlation coefficient was computed using the participants' "right," "left," and "integrated" scores and their computer programming achievement scores. Such computations result in three correlation coefficients which are used by the investigator to answer the first question of this exploratory study:

> Question One: Is there a relationship between mode of hemispheric operation and achievement in computer programming?

The correlation coefficients available to consider with respect to this question will provide information concerning how the degree to which one in this study uses the right or left hemisphere is related to how one achieves in computer programming. Means and standard deviations are also reported for students indicating greatest use of the "right," "left," and "integrated" modes of cerebral hemispheric operation.

A similar statistical procedure applies to the second question:

> Question Two: Is there a relationship between mode of hemispheric operation and attitudes toward computers?

From the data, the investigator should be able to ascertain if, for the sample of this study, the degree to which one sees the right or left hemisphere is related to how one feels about computers. For example, is a high "right" score positively or negatively correlated with a positive attitude, and if so, to what extent?

In addition, by looking at the correlations of the modes with the left, or integrated modes of cerebral hemispheric operation.

Summary

This chapter has reviewed the components of the study which were central to the investigator's exploratory research. It has presented assumptions on which the study was based and a description of the design which indicated that the one-group, pretest-posttest study was correlational and descriptive. The sample which included ten students participating in the UMass/Amherst Upward Bound program was described. And, finally, the instruments used as well as the procedure followed for data collection and analysis were explained. The next chapter will report the results of the data analysis.

CHAPTER IV

RESULTS OF THE STUDY

Introduction

In order to ascertain whether computer programming could be considered as an academic discipline which provides education for both sides of the brain, the investigator examined the relationship between right, left, and integrated modes of cerebral hemispheric operation and several variables involved in the teaching/learning process. These variables included achievement in and attitude toward computer programming and academic self concept. It was felt that information about these relationships might lead to insights not only concerning _if_ computer programming provided opportunities for the use of both logical/analytical and intuitive/global skills, but also why and in what ways. Hopefully, the data analysis presented in this chapter will provide a basis for answering the questions if, why, and how computer programming provides education for both sides of the brain.

Presentation of the data analysis for the first research question--_Is there a relationship between mode of cerebral hemispheric operation and achievement in computer programming_--will consist of Pearson product moment correlation coefficients computed using participants' scores on "Your Style of Learning and Thinking" and "ALP Assessment." In addition, achievement means and standard deviations are presented for the three students whose responses indicated greatest use of the right hemisphere. Table 2 indicates that students 1, 3, and 9 comprise this "right" group. There were also three students who indicated greatest use of the left hemisphere--students 4, 5, and 8 make up this "left" group. Finally, the "integrated" group consists of the remaining students, 2, 6, 7, and 10, who indicated that both hemispheres were used equally on many cognitive tasks.

Data analysis for the second question--Is there a relationship between mode of cerebral hemispheric operation and attitude toward computers--and the third question--Is there a relationship between mode of cerebral hemispheric operation and academic self concept (in student computer programming)--is the same. First, Pearson product moment correlation coefficients are calculated using scores indicating magnitude of each mode of cerebral hemispheric operation and combined scores on each of the instruments concerned with attitude toward computers and academic self concept. Secondly, Pearson product moment correlation coefficients are calculated using mode scores with responses to each item on the instruments. Thirdly, means and standard deviations are reported for the combined scores on each of the instruments for each group ("right," "left," and "integrated"). Finally, means and standard deviations are reported for each item on both instruments for each of the groups.

The data analysis presented for the final question--Is there a relationship between mode of cerebral hemispheric operation and specific aspects of the computer programming process--consists of frequencies of responses to items and categories on the "Programming Style" checklist as well as anecdotal data collected during the course. The investigator held a post-course interview with each participant at which time the checklist and individuals' reactions to the course and computer programming were discussed.

The chapter concludes with a summary of results presented for each question.

Analysis

Table 1 presents each of the ten participants' three scores on the self-report instrument, "Your Style of Learning and Thinking." The data provide the basis for all further data analysis presented in this chapter. Table 2 shows the breakdown of students into "right," "left," and "integrated" subgroups. The groupings were arrived at by subtracting students' right, left, and integrated raw scores from the group means for each of the categories. This resulted in three difference scores for each participant. The greatest positive difference score was used to designate the participant's "dominant" mode, or that mode which (s)he reported as using most often.

The greatest positive difference scores of students 1, 3, and 9 placed them in the "right" group. Difference scores for students 4, 5, and 8 indicated that they reported most use of the left hemisphere, placing them in the "left" group. The remaining students 2, 6, 7, and 10 make up the "integrated" group. Means for each of these groups are presented as part of the data analysis for each research question.

TABLE 1

PARTICIPANTS' RAW SCORES, GROUP MEANS AND STANDARD DEVIATIONS ON "YOUR STYLE OF LEARNING AND THINKING"

Participant		Raw Scores		
		Right	Left	Integrated
1		15	13	12
2		7	5	28
3		16	8	16
4		10	14	16
5		13	20	7
6		12	9	19
7		10	7	23
8		3	16	21
9		20	10	10
10		11	9	20
Sample	Mean	11.7	11.1	17.2
	Standard Deviation	4.5	4.3	6.0
Norm	Mean	11.3	9.1	19.6
	Standard Deviation	4.5	4.1	5.7

TABLE 2

DESIGNATION OF SUBGROUPS BASED ON PARTICIPANTS' GREATEST POSITIVE DIFFERENCE SCORE CALCULATED FROM RAW SCORES AND SAMPLE MEANS

Participant	Difference Scores			Category
	Right	Left	Integrated	
1	3.3	1.9	-5.2	Right
2	-4.7	-6.1	10.8	Integrated
3	4.3	-3.1	-1.2	Right
4	-1.7	2.9	-1.2	Left
5	1.3	8.9	-10.2	Left
6	.3	-2.1	1.8	Integrated
7	-1.7	-4.1	5.8	Integrated
8	-8.7	4.9	3.8	Left
9	8.3	-1.1	-7.2	Right
10	-.7	-2.1	2.8	Integrated

Question One

> Is there a relationship between mode of cerebral hemispheric operation and achievement in computer programming?

Right Mode of Cerebral Hemispheric Operation. The correlations presented in Table 3 indicate that, for the sample of ten participants in this study, a negative relationship existed between the right hemispheric mode of operation and achievement in computer programming. That is to say, scores reflecting greater use of the right hemisphere correlated with lower scores on the computer programming achievement test and vice versa. This relationship was significant at the .05 level of confidence. In addition, Table 4 indicates that the group mean for those students reporting greatest use of the right hemisphere was lower than the mean of the other two groups.

Left Mode of Cerebral Hemispheric Operation. For the left mode of cerebral hemispheric operation and achievement in computer programming, Table 3 indicates that there was no correlation. That is, for the sample under study, there seemed to be no relationship between scores reflecting use of the left hemisphere and scores on the computer programming achievement test. Table 4 shows a high mean for those students reporting greatest use of the left hemisphere. It is substantially higher than the students' in the "right" group and one point lower than that for those in the "integrated" group.

Integrated Cerebral Hemispheric Operation. Table 3 indicates a slightly positive correlation between the integrated mode of cerebral hemispheric operation and achievement in computer programming. In other words, those scores reflecting greater use of both cerebral hemispheres are correlated with high computer programming achievement scores. Table 4 indicates that those students reporting greatest use of both cerebral hemispheres achieved the highest mean in computer programming achievement.

TABLE 3

CORRELATIONS BETWEEN MODE OF CEREBRAL HEMISPHERIC OPERATION AND ACHIEVEMENT IN COMPUTER PROGRAMMING

Mode	Correlation Coefficient
Right	-.533*
Left	.031
Integrated	.379

*P < .05

TABLE 4

SUBGROUP MEANS AND STANDARD DEVIATIONS FOR ACHIEVEMENT IN COMPUTER PROGRAMMING

Group	Mean	Standard Deviation
Right (N=3)	8.0	3.5
Left (N=3)	13.0	5.3
Integrated (N=4)	14.0	7.0
Total (N=10)	11.9	5.7

Question Two

> Is there a relationship between mode of cerebral hemispheric operation and attitude toward computer programming?

Right Mode of Cerebral Hemispheric Operation. Table 5 presents correlations between mode of cerebral hemispheric operation and participants' attitudes toward computers. The overall attitude for the right mode was negatively correlated with attitude before the course began and was more strongly negative at the end of the course, i.e., scores indicating greater use of the right hemisphere correlated with negative attitudes about computers. This relationship was true for each of the categories within overall attitude. That is, before the course began, there was a negative relationship between scores reporting use of the right hemisphere with attitude concerning the need for knowledge about computers, with that regarding social applications of computers, and with attitude concerning personal skills in computer programming. The correlation for each was more negative after the course.

The mean responses reported in Table 6 indicate that the overall attitude toward computers of the "right" group was neutral before and after the course. Their attitude concerning the need for knowledge about computers became less positive during the course. They expressed the same somewhat negative attitude regarding social applications of computers before and after the course. Finally, their attitude concerning their personal skills in computer programming was somewhat positive at the beginning of the course and did not change.

Table 7 presents item-by-item correlations. Noteworthy is the somewhat strong positive correlations between reported use of the right hemisphere and expressed attitude to Item 10, "I think computers can replace most people's jobs," on the pre and post. Additionally, at the end of the course, correlations were strongly negative between reported use of the right hemisphere and Items 13, 14, 16, 18, and 20. Students reporting greater use of the right hemisphere tended to disagree with the following statements:

- -- high school should teach all students about how computers are used in society;
- -- computers interfere with privacy;
- -- computers cause life to be complicated;
- -- all citizens should have free access to computerized information; and,
- -- the general public does not need to know about computers.

Table 8 presents item-by-item group frequencies and mean responses to the attitude survey. Several mean responses should be noted for the "right" group. There was more agreement with Item 1, "I know everything I want to know about computers," at the end of the course. More tended to agree that computers helped make life easier (Item 2) after the course. All agreed that they would like to be able to program a computer (Item 3). More agreed that computer programming would help them in college at the end of the course (Item 7). They were unsure at the beginning and at the end of the course whether the programming they could do was important (Item 11). Fewer agreed that they could be creative in working with computers at the end of the course (Item 15). More disagreed that all citizens should have free access to computerized information (Item 16) at the end of the course.

Left Mode of Cerebral Hemispheric Operation. Table 5 indicates a slightly negative correlation existed between reported use of the left hemisphere and overall attitude toward computers before the course began and a slightly positive correlation at the end of the course. There was relatively no correlation for this mode with attitude concerning the need for knowledge about computers. A slightly negative relationship existed pre and post for the left mode and attitude concerned with social applications of computers. Finally, a moderately negative correlation changed to a moderately positive one for this mode and attitude concerning personal skills in computer programming.

The mean response for the "left" group on the entire attitude survey, reported in Table 6, indicates a slightly more positive attitude at the end of the course. Mean responses for this group were also slightly more positive at the end of the course for the categories concerning attitudes toward the need for knowledge about, and social applications of, computers. The "left" group's mean attitudes toward their personal skills in programming was significantly more positive at the end of the course.

Table 7 indicates that the positive correlation between greater use of the left hemisphere was moderate to high with the following statements:

-- I think everything I want to know about computers, Item 1, pre only;

-- I think computers make life easier, Item 2, post; and,

-- I would like to be able to program a computer, Item 3, post.

In Table 8, the mean responses for the "left" group are reported as mostly positive. Noteworthy is that all members strongly agreed that they would like to be able to program a computer, Item 3, at the end of the course. At the end of the course, mean response to the following was substantially positive:

-- I do not feel powerless when dealing with a computerized service;

-- learning to program a computer will help me in college;

-- I think everyone should know how to program a computer;

-- I can learn to program a computer;

-- the kind of programming I am able to do is important;

-- I am logical enough to work with computers;

-- I think my high school should teach all students about how computers are used in society;

-- computers do not cause life to be complicated; and,

-- computers do not interfere with my privacy.

Integrated Cerebral Hemispheric Operation. The correlation between reported use of both cerebral hemispheres and overall attitude toward computers was slightly positive before the course and slighly more positive at the end. (See Table 5.) The correlation between attitudes concerned with sub-categories--need for knowledge about computers, social applications of computers, and personal skills in computer programming--and reported use of both hemispheres were all slightly positive before and slightly more positive after the course.

The group mean responses reported in Table 6 show a slightly positive overall attitude toward computers for the "integrated" group before the course. This was slightly more positive after the course. The same result is reported for attitude concerning social application of computers and personal skills in programming. The opposite is true, that is, a pre-course positive attitude is reported as a post-course slightly less positive attitude, for attitude concerned with the need for knowledge about computers.

Item by item correlations, reported in Table 7, indicate moderately positive relationships between reported use of both hemispheres and disagreement with Item 6, "I could be replaced by a computer." Greater use of both cerebral hemispheres was also positively correlated with agreeing that high schools should teach all students about computers (Item 13). Finally, there was a shift from a negative to a positive correlation in agreement that all citizens should have free access to computerized information.

A few items to note for the "integrated" group in Table 8, all indicating less positive attitudinal reponses at the completion of the course, are the following:

-- I know everything I want to know about computers;

-- learning to program a computer will help me in college;

-- I think I can learn to program a computer;

-- I am not logical enough to work with computers;

-- I think I can be creative in working with computers; and,

-- I don't think the general public needs to know about computers.

More positive attitudes were expressed at the end of the course for these items:

-- computers can't replace most people's jobs;

-- the kind of programming I am able to do is important;

-- high schools should teach all students about how computers are used in society; and,

-- all citizens should have free access to computerized information.

TABLE 5

CORRELATION BETWEEN MODE OF CEREBRAL HEMISPHERIC OPERATION AND SELECTED CATEGORIES CONCERNING ATTITUDE TOWARD COMPUTERS, ASSESSED PRE AND POST COURSE

Category	Mode	Correlation	
		Pre	Post
Overall Attitude (Questions 1-20)	Right	-.142	-.563*
	Left	-.234	.123
	Integrated	.276	.333
Attitude Concerning Need for Knowledge About Computers (Questions 1, 8, 13, 16, 17, 20)	Right	-.140	-.631*
	Left	-.066	.080
	Integrated	.153	.416*
Attitude Concerning Social Applications of Computers (Questions 2, 5, 6, 10, 14, 18, 19)	Right	-.224	-.300
	Left	-.232	-.160
	Integrated	.336	.341
Attitude Concerning Personal Skills in Computer Programming (Questions 3, 4, 7, 9, 11, 12, 15)	Right	-.075	-.468
	Left	-.392	.351
	Integrated	.340	.400

*$p < .05$

TABLE 6

PRE-POST SUBGROUP MEANS AND STANDARD DEVIATIONS FOR SELECTED CATEGORIES CONCERNING ATTITUDE TOWARD COMPUTERS

Category	Group	Mean		Standard Deviation	
		Pre	Post	Pre	Post
Overall Attitude (Questions 1-20)	Right	3.0	3.0	1.0	0
	Left	3.0	3.7	0	.58
	Integrated	3.3	3.5	.5	.58
	Total	3.1	3.4	.57	.52
Attitude Concerning Need for Knowledge About Computers (Questions 1, 8, 13, 16, 17, 20)	Right	3.0	2.7	0	.58
	Left	3.3	3.7	.58	.58
	Integrated	3.5	3.3	.58	.96
	Total	3.3	3.2	.48	.79
Attitude Concerning Social Applications of Computers (Questions 2, 5, 6, 10, 14, 18, 19)	Right	2.7	2.7	.58	.58
	Left	2.7	3.0	.58	0
	Integrated	3.3	3.5	.50	.58
	Total	2.9	3.1	.57	.57
Attitude Concerning Personal Skills in Computer Programming (Questions 3, 4, 7, 9, 11, 12, 15)	Right	3.7	3.7	.58	.58
	Left	3.7	5.0	.58	0
	Integrated	4.3	4.3	.56	.56
	Total	3.9	4.3	.57	.82

TABLE 7

ITEM BY ITEM CORRELATIONS BETWEEN MODE OF CEREBRAL HEMISPHERIC OPERATION AND ATTITUDES TOWARDS COMPUTERS, ASSESSED PRE AND POST COURSE

Statement	Mode	Correlation	
		Pre	Post
1. I know everything I want to know about computers.	Right	.101	-.149
	Left	.668*	.325
	Integrated	-.559*	-.124
2. I think computers help make life easier.	Right	-.281	-.053
	Left	.303	.688
	Integrated	-.009	-.457
3. I would like to be able to program a computer.	Right	.054	-.421
	Left	.301	.575
	Integrated	.177	-.010
4. I feel powerless when dealing with a computerized service (bank, store, etc.)	Right	-.184	-.280
	Left	-.303	.364
	Integrated	.357	.053
5. If I had my own computer, I would not have to think as much.	Right	-.004	-.008
	Left	.059	-.576
	Integrated	.046	.422
6. I could be replaced by a computer.	Right	-.363	-.408
	Left	-.104	-.401
	Integrated	.348	.597*

*$p < .05$

TABLE 7--Continued

Statement	Mode	Correlation Pre	Correlation Post
7. Learning tc program a computer will help me in college.	Right	.203	-.195
	Left	-.256	.224
	Integrated	.033	-.016
8. I think everyone should know how to program a computer.	Right	.285	-.432
	Left	-.291	-.148
	Integrated	-.004	.431
9. I don't think I can learn to program a computer.	Right	.104	-.292
	Left	-.201	.292
	Integrated	.067	.009
10. I think computers can replace most people's jobs.	Right	.531	.506
	Left	-.322	-.246
	Integrated	-.166	-.202
11. The kind of programming I am able to do is not very important.	Right	-.233	-.465
	Left	-.471	-.069
	Integrated	.516	.299
12. I am not logical enough to work with computers.	Right	-.221	-.486
	Left	-.191	.217
	Integrated	.304	.208
13. I think my high school should teach all students about how computers are used in society.	Right	-.143	-.772*
	Left	.012	.089
	Integrated	.117	.515

*$p < .05$

TABLE 7--Continued

Statement	Mode	Correlation Pre	Correlation Post
14. I think computers cause life to be complicated.	Right	-.451	-.712*
	Left	-.197	.219
	Integrated	.481	.376
15. I think I can be creative in working with computers.	Right	-.107	-.073
	Left	-.301	.118
	Integrated	.298	.030
16. I think all citizens should have free access to computerized information.	Right	.317	-.633
	Left	.171	-.075
	Integrated	-.362	.530
17. I think every home should have a computer terminal.	Right	-.408	-.210
	Left	.103	.364
	Integrated	.233	-.105
18. I feel that computers interfere with my privacy.	Right	-.194	-.563*
	Left	-.465	.252
	Integrated	.482	.241
19. Most jobs that I would want probably require some knowledge about computers.	Right	-.071	-.205
	Left	-.006	.258
	Integrated	.058	-.033
20. I don't think the general public needs to know about computers.	Right	-.420	-.593*
	Left	-.255	.007
	Integrated	.500	.440

*$p < .05$

TABLE 8

PRE-POST SUBGROUP MEANS AND STANDARD DEVIATIONS FOR ITEMS ON COMPUTER ATTITUDE SURVEY

Item	Group	Mean		Standard Deviation	
		Pre	Post	Pre	Post
1. I know everything I want to know about computers.	Right	4.7	3.7	.58	.58
	Left	5.0	4.7	0	.58
	Integrated	4.5	4.0	.58	.80
	Total	4.7	4.1	.48	.74
2. I think computers help make life easier.	Right	3.3	3.7	.58	.58
	Left	4.0	4.3	0	.58
	Integrated	3.8	3.8	1.3	.5
	Total	3.7	3.9	.82	.57
3. I would like to be able to program a computer.	Right	4.3	4.0	.58	0
	Left	4.0	5.0	0	0
	Integrated	4.8	4.5	.5	.58
	Total	4.4	4.5	.52	.53
4. I feel powerless when dealing with a computerized service (bank, store, etc.).	Right	3.3	3.7	1.5	.58
	Left	3.0	4.3	1.0	.58
	Integrated	4.0	4.0	.82	.82
	Total	3.5	4.0	1.1	.67

TABLE 8--Continued

Item	Group	Mean Pre	Mean Post	Standard Deviation Pre	Standard Deviation Post
5. If I had my computer, I would not have to think as much.	Right	2.7	2.3	1.2	.58
	Left	2.3	1.3	.57	.58
	Integrated	2.3	2.8	1.5	1.7
	Total	2.4	2.2	1.1	1.2
6. I could be replaced by a computer.	Right	3.3	3.3	2.1	1.2
	Left	3.7	3.0	1.5	1.7
	Integrated	4.5	4.5	.58	.58
	Total	3.9	3.7	1.4	1.3
7. Learning to program a computer will help me in college.	Right	3.0	3.7	1.0	.58
	Left	2.7	4.3	1.5	.58
	Integrated	4.3	3.8	.5	1.3
	Total	3.4	3.9	1.2	.88
8. I think everyone should know how to program a computer.	Right	4.0	3.7	1.0	.58
	Left	3.0	4.0	1.0	1.0
	Integrated	3.8	3.8	.96	.96
	Total	3.6	3.8	.97	.79
9. I don't think I can learn to program a computer.	Right	4.0	4.0	1.0	1.0
	Left	3.7	5.0	.58	0
	Integrated	4.5	3.8	.58	1.9
	Total	4.3	4.2	.74	1.2

TABLE 8--Continued

Item	Group	Mean		Standard Deviation	
		Pre	Post	Pre	Post
10. I think computers can replace most people's jobs.	Right	3.7	3.3	.58	1.2
	Left	2.0	1.7	0	1.2
	Integrated	3.3	3.5	1.3	1.3
	Total	3.0	2.9	1.1	1.4
11. The kind of programming I am able to do is not very important.	Right	3.0	3.0	1.0	1.0
	Left	3.3	4.7	.58	.58
	Integrated	4.0	4.3	.82	.96
	Total	3.5	4.0	.85	1.1
12. I am not logical enough to work with computers.	Right	3.3	3.3	1.2	1.2
	Left	3.7	5.0	.58	0
	Integrated	4.5	4.0	.58	.82
	Total	3.9	4.1	.88	.9
13. I think my high school should teach all students about how computers are used in society.	Right	3.3	3.3	.58	.58
	Left	3.7	4.7	.58	.58
	Integrated	3.8	4.0	1.9	.82
	Total	3.6	4.0	1.2	.82
14. I think computers cause life to be complicated.	Right	3.0	3.3	0	.58
	Left	3.7	4.7	.58	.58
	Integrated	4.3	4.3	.96	.96
	Total	3.7	4.1	.82	.88

TABLE 8--Continued

Item	Group	Mean Pre	Mean Post	Standard Deviation Pre	Standard Deviation Post
15. I think I can be creative in working with computers.	Right	3.7	3.3	.58	.58
	Left	3.7	4.0	1.2	1.0
	Integrated	4.0	3.5	.82	.58
	Total	3.8	3.6	.79	.70
16. I think all citizens should have free access to computerized information.	Right	3.3	2.3	1.2	.58
	Left	3.3	4.0	1.2	1.7
	Integrated	3.3	3.8	.96	1.5
	Total	3.3	3.4	.95	1.4
17. I think every home should have a computer terminal.	Right	2.0	2.7	1.0	.58
	Left	3.0	3.3	0	.58
	Integrated	3.0	3.0	1.8	.82
	Total	2.7	3.0	1.3	.67
18. I feel that computers interfere with privacy.	Right	3.3	3.7	.58	.58
	Left	3.3	4.7	1.5	.58
	Integrated	4.5	4.0	.58	0
	Total	3.8	4.1	1.0	.57
19. Most jobs that I would want probably require some knowledge about computers.	Right	2.7	3.0	.58	1.0
	Left	3.3	4.0	1.2	1.0
	Integrated	3.5	3.5	.58	1.3
	Total	3.2	3.5	.79	1.1

TABLE 8--Continued

Item	Group	Mean		Standard Deviation	
		Pre	Post	Pre	Post
20. I don't think the general public needs to know about computers.	Right	3.7	3.3	.58	.58
	Left	4.0	4.3	1.0	1.2
	Integrated	4.3	3.5	.5	1.3
	Total	4.0	3.7	.67	1.1

Question Three

> Is there a relationship between mode of cerebral hemispheric operation and academic self concept?

Table 9 reflects that, for the group of ten students in this study, no significant correlations existed between mode of cerebral hemispheric operation and overall academic self concept as measured by the "Michigan State General Self Concept of Ability Scale." Table 9 also suggests similar results for each item on the instrument. The data do show more negative correlations for reported use of right mode and academic self concept, more positive ones for integrated, and more values closer to zero for the left mode. However, since the values are so tenuous and none are significant at the .05 level, no evidence is available from the correlations to support an answer to this question.

The group means, reported in Table 10, suggest that each group viewed itself as at least average in ability at the beginning of the course. The "integrated" group reported a slightly "above average" mean. There was no change in the post mean for either the "right" or "integrated" group. The "left" mean at the end of the course was slightly more positive.

Table 10 reflects several gains in group mean response on specific items. The "left" group reported most gains in positive response. These were reflected in four statements (Items 1, 3, 7, and 8). The "integrated" group responded more positively at the end of the course to three items (3, 6, and 8). The "right's" post mean response was more positive to Item 1.

Less positive responses were given at the end of the course to three items (5, 7, and 8) by the "right" group and to two items (1 and 7) by the "integrated" group. The "left" group showed no decreases in mean responses at the end of the course.

TABLE 9

CORRELATIONS BETWEEN MODE OF CEREBRAL HEMISPHERIC OPERATION AND ACADEMIC SELF CONCEPT, ASSESSED PRE AND POST COURSE

Statement	Mode	Correlation	
		Pre	Post
Overall Assessment (Questions 1-8)	Right	-.210	-.306
	Left	-.041	.219
	Integrated	.187	.072
1. How do you rate yourself in school ability compared with	Right	-.199	.093
	Left	-.017	.395
	Integrated	.162	-.356
2. How do you rate yourself in school ability compared with those in your class at school?	Right	-.053	-.394
	Left	.136	-.118
	Integrated	-.058	.381
3. Where do you think you would rank in your class in high school?	Right	-.358	-.347
	Left	-.090	.189
	Integrated	.334	.124
4. Do you think you have the ability to complete college?	Right	-.454	-.427
	Left	.216	.437
	Integrated	.185	.005
5. Where do you think you would rank in your class in college?	Right	-.160	-.005
	Left	-.118	.136
	Integrated	.206	.094

TABLE 9--Continued

Statement	Mode	Correlation Pre	Correlation Post
6. In order to become a doctor, lawyer, or university professor, work beyond four years of college is necessary. How likely do you think it is that you could complete such advanced work?	Right	-.050	-.053
	Left	-.278	-.266
	Integrated	.238	.232
7. Forget for a moment how others grade your work. In your own opinion, how good do you think your work is?	Right	.307	-.089
	Left	-.028	.500
	Integrated	-.211	-.295
8. What kind of grades do you think you are capable of getting?	Right	0	-.490
	Left	.073	0
	Integrated	-.053	.368

TABLE 10

PRE-POST SUBGROUP MEANS AND STANDARD DEVIATIONS FOR ITEMS ON ACADEMIC SELF CONCEPT INSTRUMENT

Item	Group	Mean		Standard Deviation	
		Pre	Post	Pre	Post
Overall Assessment (Questions 1-8)	Right	3.0	3.0	1.0	0
	Left	3.0	3.3	0	.58
	Integrated	3.5	3.5	.58	.58
	Total	3.2	3.3	.63	.48
1. How do you rate yourself in school ability compared with your close friends?	Right	3.0	3.3	1.0	.58
	Left	3.7	4.0	.58	1.0
	Integrated	4.0	3.5	.82	.58
	Total	3.6	3.6	.84	.70
2. How do you rate yourself in school ability compared with those in your class at school?	Right	3.0	3.0	0	0
	Left	3.3	3.3	.58	.58
	Integrated	3.5	3.8	.58	.98
	Total	3.3	3.4	.48	.70
3. Where do you think you would rate in your class in high school?	Right	3.0	3.0	0	0
	Left	3.0	3.7	1.0	.58
	Integrated	3.3	3.8	.5	.58
	Total	3.1	3.5	.57	.71

TABLE 10--Continued

Item	Group	Mean Pre	Mean Post	Standard Deviation Pre	Standard Deviation Post
4. Do you think you have the ability to complete college?	Right	4.0	4.0	1.7	1.0
	Left	4.7	4.7	.58	.58
	Integrated	4.5	4.5	.58	.58
	Total	4.4	4.4	.97	.70
5. Where do you think you would rank in your class in college?	Right	3.3	3.0	1.2	0
	Left	3.3	3.3	.58	.58
	Integrated	3.5	3.5	.58	.58
	Total	3.4	3.3	.70	.48
6. In order to become a doctor, lawyer, or university professor, work beyond four years of college is necessary. How likely do you think it is that you could complete such advanced work?	Right	3.0	3.0	2.0	1.0
	Left	3.3	3.3	.58	.58
	Integrated	4.0	4.3	.82	.96
	Total	3.5	3.6	1.2	.97
7. Forget for a moment how others grade your work. In your own opinion, how good do *you* think your work is?	Right	3.7	3.0	.58	0
	Left	3.3	4.3	.58	1.2
	Integrated	3.8	3.5	.5	.58
	Total	3.6	3.6	.52	.84

TABLE 10--Continued

Item	Group	Mean		Standard Deviation	
		Pre	Post	Pre	Post
8. What kinds of grades do you think you are capable of getting?	Right	4.0	3.3	1.0	.58
	Left	4.0	4.3	0	.58
	Integrated	4.0	4.3	.82	.5
	Total	4.0	4.0	.67	.67

Question Four

> Is there a relationship between mode of cerebral hemispheric operation and specific aspects of the programming process?

Table 11 indicates that there are very few items to which students in the three groups responded differently on the "Programming Style" checklist. It should be noted again that the numbers of students in the different groups were so small that no conclusive statements can be made regarding the validity of this instrument. However, additional information regarding this question was acquired from speaking with students and observing them while they programmed.

Concerning the initial category, Problem Identification, Questions 1-6 on the "Programming Style" checklist, there are two group differences worth noting. The first is Item 2 to which 67% of the "left" group responded that they most often chose to write programs that solved math problems; the other two groups had no students who gave this response. Secondly, to Item 5, 100% of the "right" group indicated that they usually chose to write programs that were entirely new (in content); whereas, 67% of the "left" group chose to write programs almost the same as those presented in class, and 50% of the "integrated" preferred those that built on programs presented in class.

Comments that students made regarding this "Problem Identification" phase included:

> I like being free to do what I want with the computer (a 'right' student's comment);

> Even though its school stuff, it's fun to program a computer (also coming from a student in the 'right' group);

> It's kinda' frustrating because I think of things that are too hard to do (from a student in the 'integrated' group).

Another point worth mentioning is that all students, with the exception of one, chose to write at least one program that focused exclusively on words. Examples of these are "Street-talk," "Startrek," "Spanish Drill," and "Parlez-vous Francais." These were not all simple programs--some included sophisticated branching statements and the use of sub-programs.

The second category, Problem Understanding, was intended to address cognitive process prior to the actual writing of a program. Item 7 on the checklist produced very interesting responses--100% of the "right" group said they thought about a program "as a whole"; in contrast, 100% of the "left" group said they thought about it "step by step"; 50% of the "integrated" group was in each of those response categories.

When questioned about these responses, one student in the "right" group commented:

> I know what I want my program to do and I know a collection of symbols I'll need. (When this student was asked what he thought of first, he said, 'It all happens at once--the symbols come to me when I'm thinking of what the program will do.')

Another student from the "left" group explained:

> For instance, when I wrote a program to solve an equation, I thought about how it would be step by step, just like I do it when I do homework problems.

It was interesting that this student added, "That's O.K., isn't it?"

Comments and observations were in conflict with written responses to Item 8. Most students in all groups responded in the checklist that they used symbols or pictures to help them understand. However, when questioned and observed while working, they used examples of programs presented in class as models.

Section three, Problem Analysis/Organization, was intended to address the process of implementing cognition. Half of the students--two from the "right" group and three from the "integrated"--indicated that they only needed a general overview of their problem before writing it in a programming language (Item 10). One student from the "integrated" group, commenting in this response, said, "I'm eager to write it so I can tell the computer what to do."

Only one student (from the "left" group) indicated that he used a symbol chart (flowchart) to guide his writing of a program (Item 11). This activity was not emphasized to any great extent in the course. Therefore, it was not surprising that most students responded that they used just English or a combination of words and symbols for guidance.

Written responses to Item 12 were also in conflict with stated responses and observations. Many more students than the three seemed to have only a mental image before attempting to write a program. When questioned, one student from the "integrated" group replied, "I didn't have time at the dorm to plan out what I write so I thought I'd give a shot at writing a program and have you check it before I typed it in."

Section four concerned the actual writing of an APL program. Again, written responses were incongruent with observations. Many students sat down at the terminal to type in a program with no written guidance of any sort (Item 13). One student from the "integrated" group commented that she did not want to "waste time" doing anything else when she had sole access to the terminal.

Item 14 responses indicate that most students were rather conservative in their programming. This might be the general response from novice programmers.

Group differences were apparent in responses to Item 15 concerning the loss or non-loss of control when writing a program. One hundred percent of the "right" group stated they became easily frustrated. In contrast, the entire "integrated" group maintained that they remained controlled. The "left" group were evenly divided in response. One member of the "right" group said, "That's why I don't like to write programs before typing them in. . . . Since I get frustrated, I at least enjoy typing."

To the last item in this section, most students in all groups indicated they wrote short programs. This was confirmed through observations.

The last section of the checklist, Run Analysis, was intended to address "debugging" behaviors. All students in the "right" group responded that they became frustrated if bugs could not be corrected immediately (Item 18). No students indicated that they were able to "visualize" the program's errors away from the printout (Item 19). All students in the "left" group indicated that they would analyze results to see if the program did what they intended it to do, even if there were no error reports. Most students (all in the "right" group and the majority in the other two groups) opted for the instructor's help if they could not immediately find errors (Item 22). All students in the "integrated" group stated they would sit over a printout until they figured out how to correct errors (Item 23), whereas students in the other groups were more likely to come back to errors later. More students in the "right" group responded that they would take a guess at what might cause an error (Item 24). On the other hand, all students in the "left" and most in the "integrated" were willing to carefully analyze where the error was. Finally, most students indicated they corrected errors, one at a time (Item 25).

TABLE 11

PERCENTAGES OF PARTICIPANTS' RESPONSES TO ITEMS ON PROGRAMMING BEHAVIORS CHECKLIST

Item	Group			
	Right N=3	Left N=3	Integrated N=4	Total N=10
PART I. PROBLEM IDENTIFICATION				
1. When deciding on a programming problem, do you usually				
(a) make us your own problem	67	100	100	90
(b) choose a problem the instructor has suggested	33	0	0	10
(c) modify one the instructor has suggested	0	0	0	0
2. Do you most often choose to write a program that				
(a) solves a problem in mathematics or science	0	67	0	20
(b) uses mostly words	67	33	50	50
(c) creates a picture	33	0	50	30
3. If you had the time and the ability, would you write a program that				
(a) creates electronic music	0	33	25	20
(b) plays a number game	33	33	25	30
(c) analyzes data	0	33	0	10
(d) draws a picture	33	0	25	20
(e) writes a poem	33	0	25	20

TABLE 11--Continued

Item	Group: Right N=3	Left N=3	Integrated N=4	Total N=10
4. Do you usually choose to write programs that have the computer				
(a) do just one thing	33	33	25	30
(b) do more than one thing	67	67	75	70
5. Do you usually choose to write a program that				
(a) builds on a program presented in class	0	0	50	20
(b) is entirely new	100	33	25	50
(c) is almost the same as a program presented in class	0	67	25	30
6. When deciding on a programming problem, do you usually				
(a) spend a lot of time choosing a problem you are able to do	67	67	75	70
(b) know immediately what problem you want to try	0	33	25	20
(c) get ideas from the instructor or other students	33	0	0	10

TABLE 11--Continued

Item	Group: Right N=3	Left N=3	Integrated N=4	Total N=10
PART II. PROBLEM UNDERSTANDING				
7. When thinking about a program you want to write, do you				
(a) think about it step-by-step	0	100	50	50
(b) think about it in chunks	0	0	0	0
(c) think about it as a whole	100	0	50	50
8. When thinking about a program you want to write, do you				
(a) jot down words to help you organize your thoughts	0	33	50	30
(b) use symbols or pictures to help you understand	67	67	50	60
(c) try to think of programs you've seen or used before to help you understand	33	0	0	10
9. When thinking about a program you want to write, do you				
(a) "play around" with ideas that might fit together	0	0	100	40
(b) try to carefully select ideas that will fit together	67	100	0	50
(c) just know what will work	33	0	0	10

TABLE 11--Continued

Item	Group: Right N=3	Left N=3	Integrated N=4	Total N=10
PART III. PROBLEM ANALYSIS/ORGANIZATION				
10. Before writing your program in a language for the computer, do you need				
(a) to be sure you have analyzed the problem and understand it step by step	0	0	25	10
(b) to have only a general overview of the problem	67	33	75	60
(c) to have an overview and a few substeps understood	33	67	0	30
11. Before writing your program in a language for the computer, do you				
(a) write it out line by line in English	67	33	25	40
(b) make a symbol chart to act as a guide	33	0	0	10
(c) use a combination of symbols and words for guidance	0	67	75	50

TABLE 11--Continued

Item	Group			
	Right N=3	Left N=3	Integrated N=4	Total N=10
12. Before writing your program in a language for the computer, do you need to have				
(a) a program written in English	67	33	50	50
(b) a "map" or flowchart of what will go on each line	0	67	0	20
(c) just a mental image of the program	33	C	50	30
PART IV. PROGRAM CODING				
13. When writing your program in a language for the computer, do you usually				
(a) just sit down at the terminal and type it in	33	0	0	10
(b) carefully write it in APL before sitting down at the terminal	67	100	33	60
(c) translate it to APL as you type from an English version	0	0	75	30

TABLE 11--Continued

Item	Group: Right N=3	Left N=3	Integrated N=4	Total N=10
14. When writing your program in language for the computer, do you				
(a) always use only the symbols you know will work	67	67	75	70
(b) sometimes try new symbols you have a hunch will work	0	33	25	20
(c) sometimes try anything just to see what happens	33	0	0	10
15. When writing your program in a language for the computer, do you				
(a) easily get frustrated	100	33	0	40
(b) remain controlled	0	33	100	50
(c) sometimes lose control	0	33	0	10
16. When writing your program in a language for the computer, do you usually				
(a) write short, to-the-point programs	100	33	75	70
(b) write long, wordy programs	0	33	0	10
(c) write moderately long programs	0	33	25	20

TABLE 11--Continued

Item	Group			
	Right N=3	Left N=3	Integrated N=4	Total N=10
PART V. RUN ANALYSIS				
17. After you've typed in your program, do you				
(a) display it and carefully look for errors	0	0	0	0
(b) run it to see if there are errors	100	100	50	80
(c) sometimes run it and sometimes examine it, depending on your "feel" for how it is	0	0	50	20
18. If your program has errors, do you				
(a) feel frustrated if you can't correct them immediately	100	33	25	50
(b) feel comfortable leaving the errors and coming back to correct them at some other time	0	67	25	30
(c) not bother to correct errors and go on to try another program	0	0	50	20

TABLE 11--Continued

Item	Group: Right N=3	Left N=3	Integrated N=4	Total N=10
19. If your program has errors, do you				
(a) need to see the printout in order to analyze what went wrong	33	100	50	60
(b) have the ability to visualize the program and analyze its mistakes, perhaps in your next class or while walking to lunch	0	0	0	0
(c) ask the instructor to help you find errors	67	0	50	40
20. If your program has errors, do you				
(a) know from the error report where to make a correction	0	33	0	10
(b) start at the beginning and look for errors in each line	33	33	75	50
(c) start with the line reported in error and then look through the remainder of the program	67	33	25	40

TABLE 11--Continued

Item	Group: Right N=3	Left N=3	Integrated N=4	Total N=10
21. If your program has no error reports on the first run, do you				
(a) assume it is correct	33	0	50	30
(b) analyze the results to see that it does what you want it to do	0	100	25	40
(c) repeat several runs and if there are no errors, assume it is correct	67	0	25	30
22. If your program has errors and you can't find them immediately, do you				
(a) give up	0	0	25	10
(b) experience that the error comes to you later when you're not even trying to think of it	0	33	25	20
(c) ask the instructor what to do	100	67	50	70
23. If your program has errors, do you				
(a) sit over the printout until you figure out how to correct them	0	33	100	50
(b) try to do something else for a while and come back to it later	67	67	0	40
(c) get up and walk around and try to think while you're walking	33	0	0	10

TABLE 11--Continued

Item	Group: Right N=3	Left N=3	Integrated N=4	Total N=10
24. If your program has errors, do you				
(a) take a guess at what might be wrong and try to fix it	67	0	25	30
(b) carefully analyze where your error is until you find it	0	100	75	60
(c) play a hunch where the error is	33	0	0	10
25. If your program has errors, do you				
(a) correct them one at a time	33	100	50	60
(b) correct them all at once	67	0	0	20
(c) correct the ones you easily can and try it again	0	0	50	20

Summary

This chapter has presented the results of the data collected for an exploratory study concerned with the possibility that computer programming can be considered an academic discipline that provides education for both sides of the brain. Variables of achievement in and attitude toward computer programming, academic self concept, and behaviors associated with specific aspects of the computer programming process were considered in relation to "right," "left," and "integrated" modes of cerebral hemispheric operation.

Achievement of Computer Programming

Concerning mode of cerebral hemispheric operation and computer programming achievement, the results for the sample of ten participants involved in this study indicated a negative correlation (r = .533) between right mode and achievement. A correlation close to zero (r = .031) existed for left mode and achievement. Finally, a somewhat positive relationship (r = .379) was reported for achievement and integrated mode.

The achievement mean for students reporting greatest use of the right hemisphere was lowest (m = 8.0). High achievement means were reported for students indicating greater use of the left hemisphere (m = 13.0) and those reporting most use of both hemispheres (m = 14.0).

Attitude Toward Computers

Overall expressed attitude toward computers was negatively correlated with right mode of cerebral hemispheric operation. This correlation changed from slightly negative to slightly positive during the course for the left mode. The pre and post correlations between overall attitude and integrated mode were somewhat positive.

Pre and post-course correlation coefficients reflected similar relationships between the modes and attitudinal categories. That is, a negative relationship for the right mode, a change from slightly negative to slightly positive for the left, and a somewhat positive one existed for the integrated mode with attitudes concerning the need for knowledge about computers, social applications of computers, and personal skills in computer programming.

The overall attitudinal mean for students in the "right" group was neutral before and after the course. In contrast, the mean for students in the "left" and "integrated" groups became more positive during the course. Mean attitude concerning the need for knowledge about computers dropped slightly for the "right" and "integrated" groups but increased for students in the "left" group. The mean for students reporting most use of the right hemisphere remained slightly negative for attitude concerned with social applications of computers. It dropped slightly for those reporting more use of the left hemisphere and increased slightly for those reporting greatest use of both hemispheres. Finally, mean attitude concerning personal skills in computer programming remained positive for the "right" and "integrated" groups and became substantially more positive for the "left."

Academic Self Concept

The relationship between right mode of cerebral hemispheric operation and the overall assessment of academic self concept was reflected as somewhat negative by both pre and post-course correlations. This same relationship existed for right mode and each item on the self concept scale. The most negative correlation was reported between right mode and Item 4 concerning ability to complete college.

A correlation close to zero was reported between left mode and academic self concept but changed to slightly positive after the course. Item correlations showed similar results with the most positive relationships reported between left mode and Item 4 concerning ability to complete college and Item 7 concerned with how good each thought his/her work was.

Finally, the correlation between overall academic self concept and integrated mode of cerebral hemispheric operation was close to zero. No strong relationships were reported in the item correlations.

Behaviors Associated With Aspects of the Computer Programming Process

In the Problem identification phase of computer programming, few group differences were apparent. Only students in the "left" group reported choosing to write programs that solve problems in math or science. This was the only item of note.

Responses from the Problem Understanding phase indicated that all students in the "right" group thought about a program "as a whole," whereas all students in the "left" group thought about it "step by step." In addition, all students in the "integrated" group and no other students reported "playing around" with ideas that might fit together.

No differences were evident in the Problem Analysis/Organization phase. However, in the Program Coding phase all students in the "right" group reported getting easily frustrated in contrast to all students in the "integrated" group who indicated that they remained controlled. All students in the "right" group also reported frustration in the Run Analysis phase to a much greater extent than other students. In addition, they indicated a greater need for support from the instructor. In contrast, students in the "left" and "integrated" groups indicated they would be more willing to sit over their printouts until they found errors and correct them one at a time.

Chapter V will include a discussion of the results presented in this chapter. Suggestions for further research will also be included there.

CHAPTER V

SUMMARY, CONCLUSIONS, AND SUGGESTIONS FOR FURTHER RESEARCH

Chapter I of this disssertation introduced the topic of hemispheric specialization and addressed its influence on teaching and learning in the schools of western society. Computer programming was suggested as an area in the educational curriculum which provided opportunities for students to develop the abilities of both their right and left hemispheres.

Chapter II included a review of literature relevant to the topic of study and focused on three major areas: (1) research concerned with the documentation of hemispheric functions; (2) literature concerning the implications of hemispheric specialization for living and learning in western society; and (3) literature concerned with the teaching and learning of computer programming in which students control the machine and their own intellectual development.

Chapter III outlined the exploratory research conducted by the author at the University of Massachusetts during the summer of 1977. The design of the one-group pretest-posttest correlational and descriptive study was presented. In addition, the participants, the instruments used and procedures followed for data collection and data analysis were described.

Chapter IV presented the results of the data analysis concerning the variables of achievement, attitude, and academic self concept in relationship to mode of cerebral hemispheric operation.

This final chapter will summarize the study, suggest some conclusions, and make some recommendations for further research.

Summary

Relatively recent research findings concerning the specialized functions of the hemispheres of the human brain have motivated contemporary psychologists to progress beyond their limited conception of consciousness. The traditional focus on examining the verbal-analytic left hemisphere, and on refining ways to measure its capacity, was responsible for discarding much of the essence of consciousness. Now, psychologists can no longer ignore the spatial-intuitive abilities of the right hemisphere and the boundaries of inquiry into the human mind have, once again, been extended.

Some educators have also become interested in this brain research and consequently conclude that most classroom instruction in western society's schools is oriented toward developing only left hemispheric abilities. In reaction to the discrimination against the right hemisphere, these individuals have proposed several alternatives for enhancing the visual-spatial-holistic-intuitive skills of the right hemisphere. A theme which occurs in most of the suggestions is that students be given more control over their own intellectual development. Student-controlled computing is one possible route for providing opportunities for students to be inventive and use their intuitive abilities along with their verbal and analytic abilities.

The purpose of this study was to explore if, why, and how computer programming does foster the development of a fully functioning consciousness. To investigate this topic, the author designed and offered an introductory course in computer programming during which data were collected concerning the variables of achievement, attitude, and academic self concept in relationship to mode of cerebral hemispheric operation. It was assumed that an examination of these variables, intrinsic to the teaching/learning process, would begin to provide an information base concerning how educators might view and utilize computer programming as an area of appeal for all students.

Four questions were posed by the investigator:

(1) Is there a relationship between mode of cerebral hemispheric operation and achievement in computer programming?

(2) Is there a relationship between mode of cerebral hemispheric operation and attitude toward computer programming?

(3) Is there a relationship between mode of cerebral hemispheric operation and academic self concept?

(4) Is there a relationship between mode of cerebral hemispheric operation and behaviors during specific aspects of the computer programming process?

To answer these questions, the investigator collected data via the following instruments: (1) "Your Style of Learning and Thinking," a self-report instrument used to ascertain participants' relative use of the right, left, or integrated modes of hemispheric operation; (2) "APL Assessment," constructed by the author to appraise participants' knowledge of APL and competence in using APL to program a computer; (3) "An Opinion Survey: How Do You Feel About Computers?" designed by the author to assess participants' attitudes toward computers and computer programming; (4) The "Michigan State General Self Concept of Ability Scale," selected to assess students' academic self concept; and (5) "Programming Style," designed by the author to identify behaviors of each participant during various aspects of the computer programming process.

A combination of correlational (Pearson product moment) and descriptive (frequencies, means, and standard deviations) statistics were used to present the results of the data analysis.

Results

> Question One: Is there a relationship between mode of cerebral hemispheric operation and achievement in computer programming?

Analysis of the data indicated that, for the sample of ten students under study, a negative correlation existed between right mode of cerebral hemispheric operation and achievement; approximately zero correlation between left mode and achievement; and a slightly positive correlation between integrated mode and achievement. Students in the "left" and "integrated" groups performed best on the achievement test, while the achievement test scores of those in the "right" group were substantially lower.

> Question Two: Is there a relationship between mode of cerebral hemispheric operation and attitude toward computer programming?

Correlation coefficients indicated that, for the sample of ten students, a negative relationship existed between right mode of cerebral hemispheric operation and attitude toward computers; and that a positive one existed between left and integrated modes and attitude. Group means denoted a neutral attitude for students in the "right" group and a positive one for students in the "left" and "integrated" groups.

> Question Three: Is there a relationship between mode of cerebral hemispheric operation and academic self concept (in student computer programmers)?

Correlation coefficients between academic self concept and mode of cerebral hemispheric operation indicated a negative relationship between right mode and academic self concept. A coefficient near zero existed for left and integrated modes with academic self concept. Group means suggested that each group viewed itself as at least average in academic ability at the beginning of the course and that the academic self concept of the "left" group became more positive during the course.

> Question Four: Is there a relationship between mode of cerebral hemispheric operation and behaviors during specific aspects of the computer programming process?

Due to the small number of students in each of the "right," "left," and "integrated" groups, data analysis resulted in no firm conclusion for this question. However, it was noted that only students in the "left" group most often chose to write programs that solved problems in mathematics or science. Students in the "right" and "integrated" groups preferred programming projects involving words, pictures, poems, etc. Other behaviors of note included the "right" group's report of thinking about a program "as a whole" in contrast to the "left's" "step-by-step" approach. Students in the "right" group reported much frustration in the debugging phase and indicated a greater need for support from the instructor. Students in the "left" and "integrated" groups reported that they remained controlled and were willing to patiently look for errors and correct them one at a time, on their own.

Discussion of Results

The study indicates that students reporting greater use of the left and integrated modes of cerebral hemispheric operation achieved higher, reported more positive attitudes about computers and computer programming, and communicated more positive academic self concepts than those students indicating greater use of the right mode. These results are clearly supported by the literature which indicates that schooling in western society discriminates against the right hemisphere. Even though student-controlled computing via programming was reported as offering opportunities for the expression of both right and left cognitive abilities, it could not be expected that a six-week introductory course in programming could significantly influence the knowledge, behaviors, and attitudes of students already having completed eleven or twelve years of schooling.

Anecdotal data and the experience of the author with students, reflected that all participants did become involved in the course and opened themselves up to interaction with the computer through programming. Greater openness corresponded to higher achievement which resulted in more positive attitudes about the computer and about themselves as programmers. This would seem to indicate that, as in all learning, motivation is a key factor. Even though the computer programming course was designed by the investigator to provide exciting and appealing educational opportunities for all students and to tap the abilities of both cerebral hemispheres, certain constraints naturally exist in an introductory course when it is imperative to verbally communicate, in a logical fashion, certain bits of information necessary to begin meaningful interaction with the machine. Perhaps students' prior experience in computer programming is an important variable that was not considered in this study. Perhaps prior exposure to schooling influences the interaction of students with computers through programming.

Recommendations for Further Research

Since this study was exploratory in nature and provided an investigation into a virtually untapped area of educational research, the possibilities for further examination of the topic are almost unlimited.

From experience and insights gained in conducting this initial inquiry into computer programming as an academic discipline which offers education for both halves of the brain, the author feels compelled to make the following recommendations:

1. The study should be replicated with a larger and more diverse sample of student computer programmers.
2. Additional means of assessing the variables, especially mode of cerebral hemispheric operation and computer programming behaviors, should be considered in data collection for a similar study.
3. The investigation should be repeated using variables other than achievement, attitude, and academic self concept in relationship to mode of cerebral hemispheric operation of student computer programmers.
4. The possible influence of instructor bias should be eliminated in a repeated study.

Also resulting from observations made during the exploratory study, the author suggests that broader and more sophisticated research be undertaken in this area. A few specific recommendations follow:

1. The influence of various programming languages on the use of right and left hemisphere abilities could be examined.

2. The weight of prior experience in computer programming as a variable in the use of different modes of hemispheric functioning could be explored.
3. The influence of the amount of schooling on the use of right and left hemisphere abilities by student computer programmers could be investigated.
4. The influence of western culture on the use of spatial-intuitive and verbal-analytic cognitive abilities by student computer programmers could be researched.
5. Computer programming could be compared to other academic disciplines to determine the comparative degree to which it provides education for both sides of the brain.

Concluding Statement

An intent of this dissertation was to draw attention to one of the most dynamic applications of the electronic digital computer in our society today. It has the facility to provide a total learning environment often inaccessible to the average student. It can become that hillside filled with flowers, trees, and wildlife or that physics laboratory containing pulleys, inclined planes, and cloud chambers.

It will become whatever a programmer's imagination and skills make it become.

Carl Sagan (1977) has stated:

> Since our society is so profoundly influenced by science and technology, which the bulk of our citizens understand poorly or not at all, the widespread availability in both schools and homes of inexpensive interactive computer facilities could just possibly play an important role in the continuance of our civilization (p. 221).

Before the computer can fulfill its potential in the classrooms and homes of our society, we as a civilization must be aware of the opportunities it offers and we as educators must be open to giving <u>all</u> students access to its control.

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APPENDIX A

COURSE OUTLINE

COURSE MODULES

INTRODUCTION TO COMPUTERS AND A PROGRAMMING LANGUAGE

COURSE OUTLINE

I. GETTING FAMILIAR (Week One)

   A. Brief History of Computers

   B. Applications and Limitations of Computers

   C. How a Computer Works (Hardware)

      1. Tour of University Computing Center (UCC)

      2. Sign-On-Procedure

   D. Communicating With a Computer (Software)

      1. Different Programming Languages

      2. Experience With Pre-Stored Programs

II. GAINING CONTROL -- INTRODUCTION TO APL (Week Two)

   A. Data Representation -- Numerical and Literal Arrays

   B. Primitive Functions -- +, -, x, etc.

   C. Error Reports -- How the Computer Tells the User It Does Not Understand

   D. Defined Functions -- Writing a Program

   E. Editing -- Correcting Mistakes

III. ELEMENTS OF COMMUNICATION (Week Three)

   A. Right to Left Execution

   B. Functions With Arrays

   C. Branching and Iteration

   D. System Commands

IV. FURTHER INTERACTION (Week Four)

A. "Debugging" -- Correcting Mistakes

B. Tracing a Program

C. Subprograms

V. - VI. PUTTING IT ALL TOGETHER (Weeks Five and Six)

Extensive Program Production -- Students will have the remainder of the course to work exclusively on programming projects with the support of the instructor.

INTRODUCTION TO COMPUTERS AND A PROGRAMMING LANGUAGE

MODULE ONE -- "GETTING FAMILIAR"

This introductory module is intended to provide an acquaintance with the nature of computers and some of the roles they play in society. Hardware, software, and issues surrounding the use of computers are briefly touched upon. The final session involves signing on the computer terminal.

Learning Goals

By the end of the first module, you will:

(1) have had exposure to the power, speed, and complexity of computers in use today;

(2) know that every machine has a memory, a processing unit, and input/output devices;

(3) understand that a "terminal" is not a computer;

(4) know the difference between hardware and software;

(5) know the difference between "batch" and "interactive" use of the computer;

(6) be familiar with some issues surrounding the applications and limitations of computers; and,

(7) be able to sign-on a computer terminal.

Learning Activities

During the course of this module, you will:

(1) discuss issues raised on the computer opinion survey;

(2) tour the UMass computing center;

(3) view two films (*Information Machine* and *A Computer Glossary*); and,

(4) sign on a computer terminal and work with pre-stored programs.

Assignment

Complete a short paper, poem, sketch, etc., concerned with material covered in Module One. (See assignment handout.)

INTRODUCTION TO COMPUTERS AND A PROGRAMMING LANGUAGE

MODULE TWO -- "GAINING CONTROL"

This module is intended to initiate user control of the computer by introducing A Programming Language. The representation of numerical and literal data, use of arithmetic and selected APL functions, and syntax and value errors are explained. Most significant is the introduction of writing programs.

Learning Goals

During the course of this module, you will learn:

(1) to use quotation marks in APL expressions;

(2) to use and interpret +, -, ÷, *, ⍟, ⌈, ⌊, |, ⍳, ⍴, and relational functions.

(3) to assign values to variables;

(4) to write a simplified program; and,

(5) to line edit.

Learning Activities

You will be involved in:

(1) lectures designed to introduce APL, and

(2) work at the computer terminal.

Assignments

(1) Complete daily worksheets.

(2) Write a short program.

INTRODUCTION TO COMPUTERS AND A PROGRAMMING LANGUAGE

MODULE THREE -- "ELEMENTS OF COMMUNICATION"

Module Three involves further discussion of APL, including indexing, reduction, logical functions, and rules for evaluating expressions. Monadic and dyadic use of functions is explained and branching in program definition is introduced. Finally, program editing is introduced.

Learning Goals

In Module Three, you will learn:

(1) the rules for evaluating APL expressions;

(2) to select elements from a vector by indexing;

(3) to perform functions on vectors by using the reduction function;

(4) to use logical functions;

(5) to use branching commands in writing programs;

(6) to use functions both manadically and dyadically; and,

(7) to change, add, and delete lines of a program.

Learning Activities

You will be involved in:

(1) lectures;

(2) examination of "glass-box" programs;

(3) individual help sessions intended to help you write programs; and,

(4) work at the computer terminal.

Assignments

(1) Complete daily worksheets.

(2) Write a program using branching.

(3) Demonstrate a competence in signing on the terminal and "managing" your workspaces.

INTRODUCTION TO COMPUTERS AND A PROGRAMMING LANGUAGE

MODULE FOUR -- "FURTHER INTERACTION"

In Module Four, you will learn techniques that will help you write more complicated and sophisticated programs. Use of "line labels" and subprograms will be explained. In addition, you will be working on programs in class.

Learning Goals

In Module Four, you will learn:

(1) to use line labels;

(2) to use subprograms;

(3) to further apply APL functions in writing programs.

Learning Activities

You will be involved in:

(1) class lectures;

(2) adaptation of programs presented in class with members of a group;

(3) daily work of the terminal in class and evening sessions.

Assignments

(1) Work with a group of students to adapt programs presented in class.

(2) Write a third program and store it in your workspace.

(3) Choose a project that you will complete in the next three weeks.

INTRODUCTION TO COMPUTERS AND A PROGRAMMING LANGUAGE

MODULES FIVE AND SIX -- "PUTTING IT ALL TOGETHER"

During these last two modules, you will have the opportunity to work exclusively on your own programming projects. With the support of the instructor during class time, you will be creating, typing in, running and debugging your programs.

Learning Goal

In this module, each of you will have the opportunity to experience the total programming process.

Learning Activity

You will:

(1) Choose a programming project.

(2) Conceptualize and organize a program.

(3) Write the program in APL.

(4) Type the program into the computer.

(5) Run the program and analyze the results.

(6) Debug if necessary.

Assignment

Complete a small-scope programming project. The project should include APL functions, branching commands, line labels, and the use of subprograms. Some ideas you might consider are:

-- a program that plays a dice game;

-- a program that drills arithmetic problems (+, -, ÷);

-- a program that "talks" to the user in English or a foreign language;

-- a program that solves problems in mathematics (algebra, trigonometry, etc.);

-- a program that analyzes data using statistics;

-- a program that forms plurals of words (i.e., god/gods; boss/bosses);

-- a program that finds all divisors of a positive number;

-- a program that converts words from English to Piglatin;

-- a program that adds, subtracts, multiplies, or divides <u>fractions</u>;

-- a program that shuffles a deck of 52 cards and deals a "hand".

The above are only examples. You may choose your own project. You may also choose to work with one other student on a joint project. You will have the final class days and evening sessions to complete your project.

APPENDIX B

COURSE HANDOUTS

SIGNING-ON THE COMPUTER

1. Turn power ON at the terminal.
2. Switch the coupler to ON--a green light will go on.
3. Dial 5-1611 on the telephone and wait for a high pitched tone.
4. Place the phone in the coupler--make sure you check that the phone card is in the correct direction.
5. Type I= (the equal sign is above the 5 on the keyboard so press the shift key and 5 to get the =). The press RETURN.
6. Type user number, then RETURN.
7. Type user code, then RETURN.
8. Type APLUM, then RETURN.

When the computer responds with CLR WS, you are signed on!

INTRODUCTION TO COMPUTERS AND APL

Assignment 1

Directions: Choose one activity from the following (do more if you like).

1. Think of 5 ways computers affect your life every day and describe them in no more than a one-page paper.

2. Make a sketch or drawing showing your impression of the computer.

3. Write a poem expressing your reaction to computers.

4. Write a short story about computers.

5. Think of 3 things available in society now that were not available 10 years ago because of computers. Explain in no more than a one-page paper.

6. Brainstorm 3 things that might be available 10 years from now because of advances in computer technology. Explain in no more than a one-page paper.

7. From the library or some other source, get information about the history of computers. Briefly describe in a one-page paper.

8. Describe briefly how the computer was (or could be) used in your high school.

9. Many people feel that computers interfere with their privacy. Explain in no more than a one-page paper whether you agree or disagree with them.

10. Explain in no more than a one-page paper the advantages and/or disadvantages of every citizen being able to program a computer.

INTRODUCTION TO COMPUTERS AND APL

SAMPLE PROGRAMS

```
      ∇GREETING
[1]   'HELLO'
[2]   'WHAT IS YOUR NAME?'
[3]   NAME←⍞
[4]   'HOW OLD ARE YOU?'
[5]   AGE←⎕
[6]   AGE;' IS A GOOD AGE TO LEARN ABOUT COMPUTERS ';NAME∇
```

```
      ∇BASEBALL
[1]   'THIS PROGRAM COMPUTES BATTING AVERAGE'
[2]   'HOW MANY TIMES HAVE YOU BEEN AT BAT?'
[3]   ATBAT←⎕
[4]   'HOW MANY HITS HAVE YOU HAD?'
[5]   HITS←⎕
[6]   AVERAGE←HITS÷ATBAT
[7]   'YOUR BATTING AVERAGE IS '
[8]   AVERAGE∇
```

```
      ∇FACE
[1]   S←'---------'
[2]   S
[3]   M←'   0 0   '
[4]   M
[5]   I←'    Δ    '
[6]   I
[7]   L←'   \_/   '
[8]   L
[9]   E←'_________'
[10]  E∇
```

```
      ∇DRILL
[1]   'MULTIPLY'
[2]   FIRST←? 100
[3]   FIRST
[4]   SECOND←? 100
[5]   SECOND
[6]   ANSWER←⎕
[7]   →(ANSWER=FIRST × SECOND)/1
[8]   'DUMMY, TRY AGAIN'
[9]   →6∇
```

INTRODUCTION TO COMPUTERS AND APL

WORKSHEET 1

DIRECTIONS: FROM THE CLASS PRESENTATION, COMPLETE THE FOLLOWING EXERCISES BY SHOWING HOW THE COMPUTER WOULD RESPOND. (IF YOU HAVE TIME, CHECK YOUR ANSWERS ON THE COMPUTER.)

EXAMPLE:

```
(YOU TYPE)      'HELLO'
(COMPUTER)    HELLO

(YOU TYPE)      7 + 5
(COMPUTER)    12
```

THESE ARE FOR YOU TO DO:

```
1.  'COMPUTERS ARE FUN'

2.  A←'SUMMER'
    A

3.  '8 + 3'

4.  12÷6

5.  B←'TIME'
    A,B

6.  C

7.  X←7
    Y←8
    X + Y

8.  A,Y

9.  Z←'○∆⎕'
    Z,X,Z,Y,Z

10. E←'UND'
    F←'WAR'
    G←'D BO'
    H←'UP'
    H,F,G,E

11. BYE

12. 108,000 × A

13. D←10 × 2
    A × D

14. 108,000 × Y

15. DISCOVER WHAT * DOES...
```

INTRODUCTION TO COMPUTERS AND APL

WORKSHEET 2

DIRECTIONS: SHOW WHAT THE COMPUTER WILL PRINT FOR EACH.

```
A←7
B←4
T←'WEEK'
S←' TWO'
X←3 2
Y←7 4
```

1. 'A+B'

2. A + B

3. A - X

4. B × Y

5. X + Y

6. T,S

7. A = B

8. A ≥ Y

9. X < S

10. X,T,S

11. A ⌈ Y

12. X ⌊ B

13. B | Y

14. X ≠ Y

15. WRITE A SHORT PROGRAM -- YOU MAY ADAPT ONE THAT WAS SHOWN IN CLASS (GREETING, FACE, BASEBALL) OR MAKE UP YOUR OWN. SOME EXAMPLES ARE:

    GIVEN 2 NAMES, THE COMPUTER WILL PRINT ''LOVES'' BETWEEN THEM;

    THE COMPUTER WILL FIND THE AREA OF A RECTANGLE;

    THE COMPUTER WILL DRAW A PICTURE OF A TREE.

INTRODUCTION TO COMPUTERS AND APL

WORKSHEET 3

DIRECTIONS: *UNDER EACH EXERCISE, PLACE THE RESPONSE THE COMPUTER WILL GIVE.*

```
R← 5 5 10 4 5 20
E← 3
V← 2 3 4 5 7 11 13
I← 2
E← 4
W← 5 9 2 6 7 1
```

1. ⍳E

2. I × ⍳E

3. ⍳E × I

4. (⍳E) × I

5. +/E + I × ⍳E

6. +/V × W

7. -/R < W

8. (⌈/W) - ⌊/W

9. (+/W) ÷ ⍴W

```
S←9
X←2 3 5 7 11 13
L←' AEHNRSTW '
```

10. L[7 3 2 9 1 4 6 8 2 5 6 9 1 5 2]

11. ⍴L

12. X[4] - X[1]

13. X[⍳⍴X]

14. X[⍴X]

15. ⍳S

```
A←1 1 0 0
B←1 0 1 0
```

16. A ∧ B

17. A ∨ B

18. ~B

19. ~A ∧ B

20. +/~(A ∧ ~B)∧A∨~A=B

INTRODUCTION TO COMPUTERS AND APL

THE FOLLOWING PROGRAMS USE BRANCHING, THE MEMBERSHIP FUNCTION, LINE LABELS, AND OTHER APL FUNCTIONS WITH WHICH YOU ARE FAMILIAR. EXAMINE EACH PROGRAM AND MAKE SURE YOU UNDERSTAND HOW IT WORKS.

ASSIGNMENT: *GROUP* 1 -- *ADAPT DRILL SO THAT THE USER WILL RECEIVE A ''NICE'' MESSAGE IF HIS/HER ANSWER IS CORRECT.*

GROUP 2 -- *ADAPT NUMBERGUESS SO THAT THE USER WILL GET A ''HINT'' IF HIS/HER ANSWER IS TOO LOW OR TOO HIGH.*

```
     ∇DRILL
[1] K←1
[2] PROB: 'MULTIPLY'
[3] FIRST←?10
[4] FIRST
[5] SECOND←?10
[6] SECOND
[7] GUESS: ANS←⎕
[8] →(ANS≠FIRST × SECOND)/CHANCE2
[9] K←K+1
[10] →(K>5)/END
[11] →PROB
[12] CHANCE2: 'NO TRY AGAIN'
[13] → GUESS
[14] END: 'THAT IS ALL FOR NOW. TYPE DRILL FOR MORE PROBLEMS.'∇
```

```
     ∇NUMBERGUESS
[1] BEGIN: NUMBER←?20
[2] 'I AM THINKING OF A NUMBER BETWEEN 1 AND 20'
[3] 'TRY TO GUESS IT'
[4] GUESS: ANSWER←⎕
[5] →(ANSWER=NUMBER)/END
[6] 'NO TRY AGAIN'
[7] →GUESS
[8] END: 'YOU GOT IT. WOULD YOU LIKE TO PLAY AGAIN?'
[9] ANS←⍞
[10] →('Y'∊ANS)/BEGIN
[11] →0∇
```

INTRODUCTION TO COMPUTERS AND APL

1. *EXAMINE THE FOLLOWING PROGRAM TO SEE HOW IT WORKS. ADAPT IT SO THAT IT WILL ''REBUILD'' THE WORD, LETTER-BY-LETTER.*

```
     ∇TRIANGLE

[1] W
[2] W←1↓W
[3] (0=ρW)/0
[4] →1 ∇
```

SAMPLE_RUN:

```
(YOU TYPE)   TRIANGLE 'SCREAM'

(COMPUTER)   SCREAM
             CREAM
             REAM
             EAM
             AM
             M

(ADAPT)      AM
             EAM
             REAM
             CREAM
             SCREAM
```

2. *EXAMINE THE FOLLOWING PROGRAM TO SEE HOW IT WORKS. ADAPT IT SO THAT IT WILL DECREASE THE STAIRS, BLOCK-BY-BLOCK.*

```
     ∇STAIRS Z

[1] Z
[2] →(20=ρZ)/0
[3] STAIRS Z, '□'∇
```

SAMPLE_RUN:

```
(YOU TYPE)   STAIRS '□□□□'

(COMPUTER)   □□□□
             □□□□□
             □□□□□□
             ETC.
```

3. *EXAMINE THE FOLLOWING PROGRAM TO SEE HOW IT WORKS. ADAPT IT SO THAT IT WILL STOP AFTER A CERTAIN NUMBER OF ''SLIDES''.*

```
     ∇SLIDE T

[1] T
[2] SLIDE T, T∇
```

SAMPLE_RUN:

```
(YOU TYPE)   SLIDE '□□'

(COMPUTER)   □□
             □□□□
             □□□□□□□□
             □□□□□□□□□□□□□□□□
             ETC.
```

APPENDIX C

INSTRUMENTS USED IN DATA COLLECTION:

YOUR STYLE OF LEARNING AND THINKING
OPINION SURVEY: HOW DO YOU FEEL ABOUT COMPUTERS
MICHIGAN STATE GENERAL SELF CONCEPT OF ABILITY
APL ASSESSMENT
PROGRAMMING STYLE

YOUR STYLE OF LEARNING AND THINKING
(FORM B)

Instructions: On the answer sheet provided, describe your style of learning and thinking by blackening the appropriate blanks. Try to describe your own strengths and preferences as accurately as possible.

1. (a) not good at remembering faces
   (b) not good at remembering names
   (c) equally good at remembering names and faces

2. (a) respond best to verbal instructions
   (b) respond best to instruction by example
   (c) equally responsive to verbal instruction and instruction by example

3. (a) able to express feelings and emotions freely
   (b) controlled in expression of feelings and emotions
   (c) inhibited in expression of feelings and emotions

4. (a) playful and loose in experimenting (in sports, art, extracurricular activities, etc.)
   (b) systematic and controlled in experimenting
   (c) equal preference for playful/loose and systematic/controlled ways of experimenting

5. (a) prefer classes where I have one assignment at a time
   (b) prefer classes where I am studying or working on many things at once
   (c) I have equal preference for the above type classes

6. (a) preference for multiple-choice tests
   (b) preference for essay tests
   (c) equal preference for multiple-choice and essay tests

7. (a) good at interpreting body language or the tone aspect of verbal communication
   (b) poor at interpreting body language; dependent upon what people say
   (c) equally good at intepreting body language and verbal expression

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University of Georgia
May 1976

8. (a) good at thinking up funny things to say and/or do
   (b) poor at thinking up funny things to say and/or do
   (c) moderately good at thinking up funny things to say or do

9. (a) prefer classes in which I am moving and doing things
   (b) prefer classes in which I listen to others
   (c) equal preference for classes in which I am moving and doing things and those in which I listen

10. (a) use factual, objective information in making judgments
    (b) use personal experiences and feelings in making judgments
    (c) make equal use of factual, objective information and personal experience/feelings in making judgments

11. (a) playful approach in solving problems
    (b) serious, all-business approach to solving problems
    (c) combination of playful and serious approach in solving problems

12. (a) mentally receptive and response to sounds and images more than to people
    (b) essentially self acting and creative mentally with groups of other people
    (c) equally receptive and self acting mentally regardless of setting

13. (a) almost always am able to use freely whatever is available to get work done
    (b) at times am able to use whatever is available to get work done
    (c) prefer working with proper materials, using things for what they are intended to be used for

14. (a) like for my classes or work to be planned and know exactly what I am supposed to do
    (b) like for my classes or work to be open with opportunities for flexibility and change as I go along
    (c) equal preference for classes and work that is planned and those that are open to change

15. (a) very inventive
    (b) occasionally inventive
    (c) never inventive

16. (a) think best while lying flat on back
    (b) think best while sitting upright
    (c) think best while walking or moving about

17. (a) like classes where the work has clear and immediate applications (e.g., mechanical drawing, shop, home economics)
    (b) like classes where the work does not have a clearly practical application (literature, Algebra, history)
    (c) equal preference for the above type of classes

18. (a) like to play hunches and make guesses when I am unsure about things
    (b) rather not guess or play a hunch when in doubt
    (c) play hunches and make guesses in some situations

19. (a) like to express feelings and ideas in plain language
    (b) like to express feelings and ideas in poetry, song, dance, etc.
    (c) equal preference for expressing feelings and ideas in plain language or in poetry, song, dance, etc.

20. (a) usually get many new insights from poetry, symbols, etc.
    (b) occasionally get new insights from poetry, symbols, etc.
    (c) rarely ever get new insights from poetry, symbols, etc.

21. (a) preference for simple problems
    (b) preference for complex problems
    (c) equal preference for simple and complex problems

22. (a) responsive to emotional appeals
    (b) responsive to logical, verbal appeals
    (c) equally responsive to emotional and verbal appeals

23. (a) preference for dealing with one problem at a time
    (b) preference for dealing with several problems at a time
    (c) equal preference for dealing with problems sequentially or simultaneously

24. (a) prefer to learn the well established parts of a subject
    (b) prefer to deal with theory and speculations about new subject matter
    (c) prefer to have equal parts of the two above approaches to learning

25. (a) preference for critical and analytical reading as for a book review, criticism of a movie, etc.
    (b) preference for creative, synthesizing reading as for making applications and using information to solve problems
    (c) equal preference for critical and creative reading

26. (a) preference for intuitive approach in solving problems
    (b) preference for logical approach to solving problems
    (c) equal preference for logical and intuitive approaches to solving problems

27. (a) prefer use of visualization and imagery in problem solving
    (b) prefer language and analysis of a problem in order to find solutions
    (c) no preference for either method

28. (a) preference for solving problems logically
    (b) preference for solving problems through experience
    (c) equal preference for solving problems logically or through experience

29. (a) skilled in giving verbal explanations
    (b) skilled in showing by movement and action
    (c) equally able to give verbal explanations and explanations by action and movement

30. (a) learn best from teaching which uses verbal explanation
    (b) learn best from teaching which uses visual presentation
    (c) equal preference for verbal explanation and visual presentation

31. (a) primary reliance on language in remembering and thinking
    (b) primary reliance on images in remembering and thinking
    (c) equal reliance on language and images

32. (a) preference in analyzing something that has already been completed
    (b) preference for organizing and completing something that is unfinished
    (c) no real preference for either activity

33. (a) enjoyment of talking and writing
    (b) enjoyment of drawing or manipulating objects
    (c) enjoyment of both talking/writing and drawing/manipulating

34. (a) easily lost even in familiar surroundings
    (b) easily find directions even in strange surroundings
    (c) moderately skilled in finding directions

35. (a) more creative than intellectual
    (b) more intellectual than creative
    (c) equally creative and intellectual

36. (a) like to be in noisy, crowded places where lots of things are happening at once
    (b) like to be in a place where I can concentrate on one activity to the best of my ability
    (c) sometimes like both of the above and no real preference for one over the other

37. (a) primary outside interests are aesthetically oriented, that is, artistic, musical, dance, etc.
    (b) primary outside interests are primarily practical and applied, that is, working, scouts, team sports, cheerleading, etc.
    (c) participate equally in the above two types of activities

38. (a) vocational interests are primarily in the general areas of business, economics, and the hard sciences; i.e., chemistry, biology, physics, etc.
    (b) vocational interests are primarily in the general areas of the humanities and soft sciences; i.e., history, sociology, psychology, etc.
    (c) am undecided or have no preference at this time

39. (a) prefer to learn details and specific facts
    (b) prefer a general overview of a subject, i.e., look at the whole picture
    (c) prefer overview intermixed with specific facts and details

40. (a) mentally receptive and responsive to what I hear and read
    (b) mentally searching, questioning, and self-initiating in learning
    (c) equally receptive/responsive and searching/self-initiating

AN OPINION SURVEY: HOW DO YOU FEEL ABOUT COMPUTERS

Directions: Please circle the response which indicates how much you agree or disagree with each statement.

1. I know everything I want to know about computers.

   Strongly Agree   Agree   Unsure   Disagree   Strongly Disagree

2. I think computers help make life easier.

   Strongly Agree   Agree   Unsure   Disagree   Strongly Disagree

3. I would like to be able to program a computer.

   Strongly Agree   Agree   Unsure   Disagree   Strongly Disagree

4. I feel powerless when dealing with a computerized service (bank, store, etc.).

   Strongly Agree   Agree   Unsure   Disagree   Strongly Disagree

5. If I had my own computer, I would not have to think as much.

   Strongly Agree   Agree   Unsure   Disagree   Strongly Disagree

6. I could be replaced by a computer.

Strongly Agree   Agree   Unsure   Disagree   Strongly Disagree

7. Learning to program a computer will help me in college.

Strongly Agree   Agree   Unsure   Disagree   Strongly Disagree

8. I think everyone should know how to program a computer.

Strongly Agree   Agree   Unsure   Disagree   Strongly Disagree

9. I don't think I can learn to program a computer.

Strongly Agree   Agree   Unsure   Disagree   Strongly Disagree

10. I think computers can replace most people's jobs.

Strongly Agree   Agree   Unsure   Disagree   Strongly Disagree

11. The kind of programming I am able to do is not very important.

Strongly Agree   Agree   Unsure   Disagree   Strongly Disagree

12. I am not logical enough to work with computers.

Strongly Agree   Agree   Unsure   Disagree   Strongly Disagree

13. I think my high school should teach all students about how computers are used in society.

Strongly Agree   Agree   Unsure   Disagree   Strongly Disagree

14. I think computers cause life to be complicated.

Strongly Agree   Agree   Unsure   Disagree   Strongly Disagree

15. I think I can be creative in working with computers.

Strongly Agree   Agree   Unsure   Disagree   Strongly Disagree

16. I think all citizens should have free access to computerized information.

Strongly Agree   Agree   Unsure   Disagree   Strongly Disagree

17. I think every home should have a computer terminal.

Strongly Agree   Agree   Unsure   Disagree   Strongly Disagree

18. I feel that computers interfere with my privacy.

Strongly Agree   Agree   Unsure   Disagree   Strongly Disagree

19. Most jobs that I would want probably require some knowledge about computers.

Strongly Agree   Agree   Unsure   Disagree   Strongly Disagree

20. I don't think the general public needs to know about computers.

Strongly Agree   Agree   Unsure   Disagree   Strongly Disagree

MICHIGAN STATE GENERAL SELF CONCEPT OF ABILITY SCALE

Circle the letter in front of the statement which best answers each question.

1. How do you rate yourself in school ability compared with your close friends?

    a. I am the best.
    b. I am above average.
    c. I am average.
    d. I am below average.
    e. I am the poorest.

2. How do you rate yourself in school compared with those in your class at school?

    a. I am among the best.
    b. I am above average.
    c. I am average.
    d. I am below average.
    e. I am among the poorest.

3. Where do you think you would rank in your class in high school?

    a. Among the best.
    b. Above average.
    c. Average.
    d. Below average.
    e. Among the poorest.

4. Do you think you have the ability to complete college?

    a. Yes, definitely.
    b. Yes, probably.
    c. Not sure either way.
    d. Probably not.
    e. No.

5. Where do you think you would rahk in your class in college?

    a. Among the best.
    b. Above average.
    c. Average.
    d. Below average.
    e. Among the poorest.

6. In order to become a doctor, lawyer, or university professor, work beyond four years of college is necessary. How likely do you think it is that you could complete such advanced work?

    a. Very likely.
    b. Somewhat likely.
    c. Not sure either way.
    d. Unlikely.
    e. Most unlikely.

7. Forget for a moment how others grade your work. In your own opinion, how good do <u>you</u> think your work is?

    a. My work is excellent.
    b. My work is good.
    c. My work is average.
    d. My work is below average.
    e. My work is much below average.

8. What kind of grades do you think you are capable of getting?

    a. Mostly A's.
    b. Mostly B's.
    c. Mostly C's.
    d. Mostly D's.
    e. Mostly F's.

APL ASSESSMENT

DIRECTIONS: BENEATH EACH TYPED COMMAND, WRITE THE RESPONSE THE COMPUTER WILL GIVE.

```
C←3
O←'COMPUTER'
M←2 4 6 10
P←'SUMMER'
U←1 3 6 7
T←14
E←'*'
R←100
```

```
1.  ⍳C
__________

2.  C|T
__________

3.  O,' ',P
__________

4.  C*2
__________

5.  +/M
__________

6.  M=U
__________

7.  C∊U
__________

8.  U⌈M
__________

9.  ⍴P
__________

10.  2⍴E
__________

11.  A
__________

12.  O[3 2 4]
__________

13.  1 0 0 0 1 1 1 0/O
__________

14.  ∨/O∊P
__________

15.  5+4×2
__________

16.  ⍳6+5|4×3⌈2
__________
```

PROGRAM MODIFICATION

BELOW IS A PROGRAM THAT NEVER STOPS. SHOW HOW YOU COULD CHANGE IT SO THAT IT WOULD STOP AFTER GIVING FIVE PROBLEMS.

```
      ∇ADD
[1]   'ADD'
[2]   A←?50
[3]   A
[4]   B←?100
[5]   B
[6]   ANSWER←⎕
[7]   →(ANSWER=A+B)/1
[8]   'SORRY TRY AGAIN'
[9]   →6∇
```

PROGRAM EXAMINATION

LOOK AT THE FOLLOWING PROGRAM AND DETERMINE WHAT IT INSTRUCTS THE COMPUTER TO DO. (1) IN THE SPACE BELOW, INDICATE WHAT THE COMPUTER WOULD PRINT IF YOU TYPED ''PROGRAM''. (2) WHAT MIGHT BE A BETTER NAME FOR ''PROGRAM''?

```
      ∇PROGRAM
[1]   A←5
[2]   A
[3]   A←A+5
[4]   A
[5]   →(A≥100)/0
[6]   →3∇
```

PROGRAM DEFINITION

CHOOSE ONE FROM THE FOLLOWING:

1. *WRITE A PROGRAM THAT FINDS THE AREA OF ANY TRIANGLE.* $(A=(H\times B)\div 2)$

2. *WRITE A PROGRAM THAT TELLS HOW MANY VOWELS ARE IN A WORD THE USER TYPES IN.*

3. *WRITE A PROGRAM THAT DRAWS A PICTURE OF A HOUSE.*

PROGRAMMING STYLE

Directions: Describe what you did during different steps of computer programming by placing a checkmark in front of one response for each statement. If you check the "other" category, please explain as best you can what you did do.

PART I. PROBLEM IDENTIFICATION

1. When deciding on a programming problem, do you usually

___ (a) make up your own problem
___ (b) choose a problem the instructor has suggested
___ (c) modify one the instructor has suggested
___ (d) Other: Please Explain ______________________________

2. Do you most often choose to write a program that

___ (a) solves a problem in mathematics or science
___ (b) uses mostly words
___ (c) creates a picture
___ (d) Other: Please Explain ______________________________

3. If you had the time and the ability, would you write a program that

___ (a) creates electronic music
___ (b) plays a number game
___ (c) analyzes data
___ (d) draws a picture
___ (e) writes a poem
___ (f) Other: Please Explain ______________________________

4. Do you usually choose to write programs that have the computer

___ (a) do just one thing
___ (b) do more than one thing
___ (c) Other: Please Explain ______________________________

5. Do you usually choose to write a program that

___ (a) builds on a program presented in class
___ (b) is entirely new
___ (c) is almost the same as a program presented in class
___ (d) Other: Please Explain ____________________

6. When deciding on a programming problem, do you usually

___ (a) spend a lot of time choosing a problem you are able to do
___ (b) know immediately what problem you want to try
___ (c) get ideas from the instructor or other students
___ (d) Other: Please Explain ____________________

II. PROBLEM UNDERSTANDING

7. When thinking about a program you want to write, do you

___ (a) think about it step-by-step
___ (b) think about it in chunks
___ (c) think about it as a whole
___ (d) Other: Please Explain ____________________

8. When thinking about a program you want to write, do you

___ (a) jot down words to help you organize your thoughts
___ (b) use symbols or pictures to help you understand
___ (c) try to think of programs you've seen or used before to help you understand

9. When thinking about a program you want to write, do you

___ (a) "play around" with ideas that might fit together
___ (b) try to carefully select ideas that will fit together
___ (c) just know what will work
___ (d) Other: Please Explain ____________________

III. PROBLEM ANALYSIS/ORGANIZATION

10. Before writing your program in a language for the computer, do you need

___ (a) to be sure you have analyzed the problem and understand it step by step
___ (b) to have only a general overview of the problem
___ (c) to have an overview and a few substeps understood
___ (d) Other: Please Explain ______________

11. Before writing your program in a language for the computer, do you

___ (a) write it out line by line in English
___ (b) make a symbol chart (or flowchart) to act as a guide
___ (c) use a combination of symbols and words for guidance
___ (d) Other: Please Explain ______________

12. Before writing your program in a language for the computer, do you need to have

___ (a) a program written in English
___ (b) a "map" or flowchart of what will go on each line
___ (c) just a mental image of the program
___ (d) Other: Please Explain ______________

IV. PROGRAM CODING

13. When writing your program in a language for the computer, do you usually

___ (a) just sit down at the terminal and type it in
___ (b) carefully write it in APL before sitting down at the terminal
___ (c) translate it to APL as you type an English version
___ (d) Other: Please Explain ______________

14. When writing your program in a language for the computer, do you

___ (a) always use only the symbols you know will work
___ (b) sometimes try new symbols you have a hunch will work
___ (c) sometimes try anything just to see what happens
___ (d) Other: Please Explain ______________

15. When writing your program in a language for the computer, do you

___ (a) easily get frustrated
___ (b) remain controlled
___ (c) sometimes lose control
___ (d) Other: Please Explain ______________________________

16. When writing your program in a language for the computer, do you usually

___ (a) write short, to-the-point programs
___ (b) write long, wordy programs
___ (c) write moderately long programs
___ (e) Other: Please Explain ______________________________

V. RUN ANALYSIS

17. After you've typed in your program, do you

___ (a) display it and carefully look for errors
___ (b) run it to see if there are errors
___ (c) sometimes run it and sometimes examine it, depending on your "feel" for how it is
___ (d) Other: Please Explain ______________________________

18. If your program has errors, do you

___ (a) feel frustrated if you can't correct them immediately
___ (b) feel comfortable leaving the errors and coming back to correct them at some other time
___ (c) not bother to correct errors and go on to try another program
___ (d) Other: Please Explain ______________________________

19. If your program has errors, do you

___ (a) need to see the printout in order to analyze what went wrong
___ (b) have the ability to visualize the program and analyze its mistakes, perhaps in your next class or while walking to lunch
___ (c) ask the instructor to help you find errors
___ (d) Other: Please Explain ______________________________

20. If your program has errors, do you

___ (a) know from the error report where to make a correction
___ (b) start at the beginning and look for errors in each line
___ (c) start with the line reported in error and then look through the remainder of the program
___ (d) Other: Please Explain ______________________

21. If your program has no error reports on the first run, do you

___ (a) assume it is correct
___ (b) analyze the results to see that it does what you want it to
___ (c) repeat several runs and if there are no errors, assume it is correct
___ (d) Other: Please Explain ______________________

22. If your program has errors and you can't figure out immediately how to correct them, do you

___ (a) give up
___ (b) experience that the error comes to you later when you're not even trying to think of it
___ (c) ask the instructor what to do
___ (d) Other: Please Explain ______________________

23. If your program has errors, do you

___ (a) sit over the printout until you figure out how to correct them
___ (b) try to do something else for a while and come back to it later
___ (c) get up and walk around and try to think while your're walking
___ (d) Other: Please Explain ______________________

24. If your program has errors, do you

___ (a) take a guess at what might be wrong and try to fix it
___ (b) carefully analyze where your error is until you find it
___ (c) play a hunch where the error is
___ (d) Other: Please Explain ______________________

25. If your program has errors, do you

___ (a) correct one at a time
___ (b) correct them all at once
___ (c) correct the ones you easily can and try it again
___ (d) Other: Please Explain ______________________________

APPENDIX D

TABLES INDICATING ITEM BY ITEM RESPONSE FREQUENCIES ON THE COMPUTER ATTITUDE SURVEY AND THE ACADEMIC SELF CONCEPT INSTRUMENT

TABLE 12

PERCENTAGES OF PARTICIPANTS' RESPONSES TO ITEMS ON COMPUTER ATTITUDE SURVEY

Statement	Group: Right N=3 Pre	Right N=3 Post	Left N=3 Pre	Left N=3 Post	Integrated N=4 Pre	Integrated N=4 Post	Total Group N=10 Pre	Total Group N=10 Post
1. I know everything I want to know about computers.								
(a) Strongly agree	0	0	0	0	0	0	0	0
(b) Agree	0	0	0	0	0	0	0	0
(c) Unsure	0	33	0	0	0	25	0	20
(d) Disagree	33	67	0	33	50	50	30	50
(e) Strongly disagree	67	0	100	67	50	25	70	30
Mean	4.7	3.7	5.0	4.7	4.5	4.0	4.7	4.1
Standard Deviation	.58	.58	0	.58	.58	.80	.48	.74
2. I think computers help make life easier.								
(a) Strongly agree	0	0	0	33	25	0	10	10
(b) Agree	33	67	100	67	50	75	60	70
(c) Unsure	67	33	0	0	0	25	20	20
(d) Disagree	0	0	0	0	25	0	10	0
(e) Strongly disagree	0	0	0	0	0	0	0	0
Mean	3.3	3.7	4.0	4.3	3.8	3.8	3.7	3.9
Standard Deviation	.58	.53	0	.58	1.3	.5	.82	.57
3. I would like to be able to program a computer.								
(a) Strongly agree	33	0	0	100	75	50	40	50
(b) Agree	67	100	100	0	25	50	60	50
(c) Unsure	0	0	0	0	0	0	0	0
(d) Disagree	0	0	0	0	0	0	0	0
(e) Strongly disagree	0	0	0	0	0	0	0	0
Mean	4.3	4.0	4.0	5.0	4.8	4.5	4.4	4.5
Standard Deviation	.58	0	0	0	.5	.58	.52	.53

TABLE 12--Continued

Statement	Right N=3 Pre	Right N=3 Post	Left N=3 Pre	Left N=3 Post	Integrated N=4 Pre	Integrated N=4 Post	Total Group N=10 Pre	Total Group N=10 Post
4. I feel powerless when dealing with a computerized service (bank, store, etc.).								
(a) Strongly agree	0	0	0	0	0	0	0	0
(b) Agree	33	0	33	0	0	0	20	0
(c) Unsure	33	33	33	0	25	25	30	20
(d) Disagree	0	67	33	67	50	50	30	60
(e) Strongly disagree	33	0	0	33	25	25	20	20
Mean	3.3	3.7	3.0	4.3	4.0	4.0	3.5	4.0
Standard Deviation	1.5	.58	1.0	.58	.82	.82	1.1	.67
5. If I had my own computer, I would not have to think as much.								
(a) Strongly agree	0	0	0	0	0	25	0	10
(b) Agree	33	0	0	0	25	0	20	20
(c) Unsure	0	33	33	0	25	25	20	0
(d) Disagree	67	67	67	33	0	25	40	40
(e) Strongly disagree	0	0	0	67	50	25	20	30
Mean	2.7	2.3	2.3	1.3	2.3	2.8	2.4	2.2
Standard Deviation	1.2	.58	.57	.58	1.5	1.7	1.1	1.2
6. I could be replaced by a computer.								
(a) Strongly agree	33	0	0	0	0	0	10	0
(b) Agree	0	33	33	67	0	0	10	30
(c) Unsure	0	0	0	0	0	0	0	0
(d) Disagree	33	67	33	33	50	50	40	40
(e) Strongly disagree	33	0	33	0	50	50	40	30
Mean	3.3	3.3	3.7	3.0	4.5	4.5	3.9	3.7
Standard Deviation	2.1	1.2	1.5	1.7	.58	.58	1.4	1.3

TABLE 12--Continued

Statement	Group							
	Right N=3		Left N=3		Integrated N=4		Total Group N=10	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post
7. Learning to program a computer will help me in college.								
(a) Strongly agree	0	0	0	33	25	25	10	20
(b) Agree	33	67	33	67	75	50	50	60
(c) Unsure	33	33	33	0	0	0	20	10
(d) Disagree	33	0	0	0	0	25	10	10
(e) Strongly disagree	0	0	33	0	0	0	10	0
Mean	3.0	3.7	2.7	4.3	4.3	3.8	3.4	3.9
Standard Deviation	1.0	.58	1.5	.58	.5	1.3	1.2	.88
8. I think everyone should know how to program a computer.								
(a) Strongly agree	33	0	0	33	25	25	20	20
(b) Agree	33	67	33	33	25	25	30	40
(c) Unsure	33	33	33	33	50	50	40	40
(d) Disagree	0	0	33	0	0	0	10	0
(e) Strongly disagree	0	0	0	0	0	0	0	0
Mean	4.0	3.7	3.0	4.0	3.8	3.8	3.6	3.8
Standard Deviation	1.0	.58	1.0	1.0	.96	.96	.97	.79
9. I don't think I can learn to program a computer.								
(a) Strongly agree	0	0	0	0	0	25	0	10
(b) Agree	0	0	0	0	0	0	0	0
(c) Unsure	33	0	33	0	0	0	20	0
(d) Disagree	33	100	67	0	50	25	50	40
(e) Strongly disagree	33	0	0	100	50	50	30	50
Mean	4.0	4.0	3.7	5.0	4.5	3.8	4.3	4.2
Standard Deviation	1.0	1.0	.58	0	.58	1.9	.74	1.2

TABLE 12--Continued

Statement	Right N=3 Pre	Right N=3 Post	Left N=3 Pre	Left N=3 Post	Integrated N=4 Pre	Integrated N=4 Post	Total Group N=10 Pre	Total Group N=10 Post
10. I think computers can replace most people's jobs.								
(a) Strongly agree	0	0	0	67	0	0	0	20
(b) Agree	0	33	100	0	25	25	40	20
(c) Unsure	33	0	0	33	0	25	30	20
(d) Disagree	67	67	0	0	50	25	20	30
(e) Strongly disagree	0	0	0	0	25	25	10	10
Mean	3.7	3.3	2.0	1.7	3.3	3.5	3.0	2.9
Standard Deviation	.58	1.2	0	1.2	1.3	1.3	1.1	1.4
11. The kind of programming I am able to do is not very important.								
(a) Strongly agree	0	0	0	0	0	0	0	0
(b) Agree	33	33	0	0	0	0	10	10
(c) Unsure	33	33	67	0	25	25	40	20
(d) Disagree	33	33	33	33	50	25	40	30
(e) Strongly disagree	0	0	0	67	25	50	10	40
Mean	3.0	3.0	3.3	4.7	4.0	4.3	3.5	4.0
Standard Deviation	1.0	1.0	.58	.58	.82	.96	.85	1.1
12. I am not logical enough to work with computers.								
(a) Strongly agree	0	0	0	0	0	0	0	0
(b) Agree	33	33	0	0	0	0	10	10
(c) Unsure	0	0	33	0	0	25	10	10
(d) Disagree	67	67	67	0	50	50	60	40
(e) Strongly disagree	0	0	0	100	50	25	20	40
Mean	3.3	3.3	3.7	5.0	4.5	4.0	3.9	4.1
Standard Deviation	1.2	1.2	.58	0	.58	.82	.88	.9

TABLE 12--Continued

Statement	Group: Right N=3 Pre	Right N=3 Post	Left N=3 Pre	Left N=3 Post	Integrated N=4 Pre	Integrated N=4 Post	Total Group N=10 Pre	Total Group N=10 Post
13. I think my high school should teach all students about how computers are used in society.								
(a) Strongly agree	33	33	0	67	50	25	20	30
(b) Agree	67	67	67	33	25	50	40	40
(c) Unsure	0	0	33	0	0	25	0	30
(d) Disagree	0	0	0	0	0	0	30	0
(e) Strongly disagree	0	0	0	0	25	0	10	0
Mean	3.3	3.3	3.7	4.7	3.8	4.0	3.6	4.0
Standard Deviation	.58	.58	.58	.58	1.9	.82	1.2	.82
14. I think computers cause life to be complicated.								
(a) Strongly agree	0	0	0	0	0	0	0	0
(b) Agree	0	0	0	0	0	0	0	0
(c) Unsure	100	67	33	0	25	25	50	30
(d) Disagree	0	33	67	33	25	25	30	30
(e) Strongly disagree	0	0	0	67	50	50	20	40
Mean	3.0	3.3	3.7	4.7	4.3	4.3	3.7	4.1
Standard Deviation	0	.58	.58	.58	.96	.96	.82	.88
15. I think I can be creative in working with computers.								
(a) Strongly agree	0	0	33	33	25	0	20	10
(b) Agree	67	33	0	33	50	50	40	40
(c) Unsure	33	67	67	33	25	50	40	50
(d) Disagree	0	0	0	0	0	0	0	0
(e) Strongly disagree	0	0	0	0	0	0	0	0
Mean	3.7	3.3	3.7	4.0	4.0	3.5	3.8	3.6
Standard Deviation	.58	.58	1.2	1.0	.82	.58	.79	.70

TABLE 12--Continued

Statement	Group: Right N=3 Pre	Right Post	Left N=3 Pre	Left Post	Integrated N=4 Pre	Integrated Post	Total Group N=10 Pre	Total Group Post
16. I think all citizens should have free access to computerized information.								
(a) Strongly agree	0	0	0	67	0	50	0	40
(b) Agree	67	0	67	0	50	0	60	0
(c) Unsure	0	33	0	0	25	25	10	20
(d) Disagree	33	67	33	33	25	25	30	40
(e) Strongly disagree	0	0	0	0	0	0	0	0
Mean	3.3	2.3	3.3	4.0	3.3	3.8	3.3	3.4
Standard Deviation	1.2	.58	1.2	1.7	.96	1.5	.95	1.4
17. I think every home should have a computer terminal.								
(a) Strongly agree	0	0	0	0	25	0	10	0
(b) Agree	0	0	0	33	25	25	10	20
(c) Unsure	33	67	100	67	0	50	40	60
(d) Disagree	33	33	0	0	25	25	20	20
(e) Strongly disagree	33	0	0	0	25	0	20	0
Mean	2.0	2.7	3.0	3.3	3.0	3.0	2.7	3.0
Standard Deviation	1.0	.58	0	.58	1.8	.82	1.3	.67
18. I feel that computers interfere with my privacy.								
(a) Strongly agree	0	0	0	0	0	0	0	0
(b) Agree	0	0	33	0	0	0	10	10
(c) Unsure	67	33	33	0	0	0	30	70
(d) Disagree	33	67	0	33	50	100	30	20
(e) Strongly disagree	0	0	33	67	50	0	30	0
Mean	3.3	3.7	3.3	4.7	4.5	4.0	3.8	4.1
Standard Deviation	.58	.58	1.5	.58	.58	0	1.0	.57

TABLE 12--Continued

Statement	Group							
	Right N=3		Left N=3		Integrated N=4		Total Group N=10	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post
19. Most jobs that I would want probably require some knowledge about computers.								
(a) Strongly agree	0	0	0	33	0	25	0	20
(b) Agree	0	33	67	33	50	25	40	30
(c) Unsure	67	33	0	33	50	25	40	30
(d) Disagree	33	33	33	0	0	25	20	20
(e) Strongly disagree	0	0	0	0	0	0	0	0
Mean	2.7	3.0	3.3	4.0	3.5	3.5	3.2	3.5
Standard Deviation	.58	1.0	1.2	1.0	.58	1.3	.79	1.1
20. I don't think the general public needs to know about computers.								
(a) Strongly agree	0	0	0	0	0	0	0	0
(b) Agree	0	0	0	0	0	25	0	10
(c) Unsure	33	67	33	33	0	25	20	30
(d) Disagree	67	33	33	0	75	25	60	40
(e) Strongly disagree	0	0	33	67	25	25	20	20
Mean	3.7	3.3	4.0	4.3	4.3	3.5	4.0	3.7
Standard Deviation	.58	.58	1.0	1.2	.5	1.3	.67	1.1

TABLE 13

PERCENTAGES OF PARTICIPANTS' RESPONSES TO ITEMS CONCERNING ACADEMIC SELF CONCEPT

Statement	Group							
	Right N=3		Left N=3		Integrated N=4		Total Group N=10	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post
1. How do you rate yourself in school ability compared with your close friends?								
(a) Among the best	0	0	0	33	25	0	10	10
(b) Above average	33	33	67	33	50	50	30	40
(c) Average	33	67	33	33	25	50	50	50
(d) Below average	33	0	0	0	0	0	10	0
(e) Among the poorest	0	0	0	0	0	0	0	0
Mean	3.0	3.3	3.7	4.0	4.0	3.5	3.6	3.6
Standard Deviation	1.0	.58	.58	1.0	.82	.58	.84	.70
2. How do you rate yourself in school ability compared with those in your class at school?								
(a) Among the best	0	0	0	0	0	25	0	10
(b) Above average	0	0	33	33	50	25	30	20
(c) Average	100	100	67	67	50	50	70	70
(d) Below average	0	0	0	0	0	0	0	0
(e) Among the poorest	0	0	0	0	0	0	0	0
Mean	3.0	3.0	3.3	3.3	3.5	3.8	3.3	3.4
Standard Deviation	0	0	.58	.58	.58	.98	.48	.70
3. Where do you think you would rank in your class in high school?								
(a) Among the best	0	0	0	0	0	25	0	10
(b) Above average	0	0	33	67	25	25	20	30
(c) Average	100	100	33	33	75	50	70	60
(d) Below average	0	0	33	0	0	0	10	0
(e) Among the poorest	0	0	0	0	0	0	0	0
Mean	3.0	3.0	3.0	3.7	3.3	3.8	3.1	3.5
Standard Deviation	0	0	1.0	.58	.5	.58	.57	.71

TABLE 13--Continued

Statement	Right N=3 Pre	Right N=3 Post	Left N=3 Pre	Left N=3 Post	Integrated N=4 Pre	Integrated N=4 Post	Total Group N=10 Pre	Total Group N=10 Post
4. Do you think you have the ability to complete college?								
(a) Yes, definitely	67	33	67	67	50	50	60	50
(b) Yes, probably	0	33	33	33	50	50	30	40
(c) Not sure either way	0	33	0	0	0	0	0	10
(d) Probably not	33	0	0	0	0	0	10	0
(e) No	0	0	0	0	0	0	0	0
Mean	4.0	4.0	4.7	4.7	4.5	4.5	4.4	4.4
Standard Deviation	1.7	1.0	.58	.58	.58	.58	.97	.70
5. Where do you think you would rank in your class in college?								
(a) Among the best	0	0	0	0	0	0	0	0
(b) Above average	67	0	33	33	50	50	50	70
(c) Average	0	100	67	67	50	50	40	30
(d) Below average	33	0	0	0	0	0	10	0
(e) Among the poorest	0	0	0	0	0	0	0	0
Mean	3.3	3.0	3.3	3.3	3.5	3.5	3.4	3.3
Standard Deviation	1.2	0	.58	.58	.58	.58	.70	.48
6. In order to become a doctor, lawyer, or university professor, work beyond four years of college is necessary. How likely do you think it is that you could complete such advanced work?								
(a) Very likely	33	0	0	0	25	50	20	20
(b) Somewhat likely	0	33	33	33	50	25	30	30
(c) Not sure either way	33	33	67	67	25	25	40	40
(d) Unlikely	0	33	0	0	0	0	0	10
(e) Most unlikely	33	0	0	0	0	0	10	0
Mean	3.0	3.0	3.3	3.3	4.0	4.3	3.5	3.6
Standard Deviation	2.0	1.0	.58	.58	.82	.96	1.2	.97

TABLE 13--Continued

Statement	Right N=3 Pre	Right N=3 Post	Left N=3 Pre	Left N=3 Post	Integrated N=4 Pre	Integrated N=4 Post	Total Group N=10 Pre	Total Group N=10 Post
7. Forget for a moment how others grade your work. In your own opinion, how good do you think your work is?								
(a) Excellent	0	0	0	67	0	0	0	20
(b) Good	67	0	33	0	75	50	60	20
(c) Average	33	100	67	33	25	50	30	60
(d) Below average	0	0	0	0	0	0	0	0
(e) Much below average	0	0	0	0	0	0	0	0
Mean	3.7	3.0	3.3	4.3	3.8	3.5	3.6	3.6
Standard Deviation	.58	0	.58	1.2	.5	.58	.52	.84
8. What kind of grades do you think you are capable of getting?								
(a) Mostly A's	33	0	0	33	25	0	20	20
(b) Mostly B's	33	33	100	67	50	25	60	60
(c) Mostly C's	33	67	0	0	25	75	20	20
(d) Mostly D's	0	0	0	0	0	0	0	0
(e) Mostly F's	0	0	0	0	0	0	0	0
Mean	4.0	3.3	4.0	4.3	4.0	4.3	4.0	4.0
Standard Deviation	1.0	.58	0	.58	.82	.5	.67	.67

APPENDIX E

LETTERS OF PERMISSION

June 28, 1977

Ms. Sally Coppus
School of Education - Room 211
University of Massachusetts
Amherst, Massachusetts 01003

Dear Ms. Coppus,

This letter is intended to provide you with written consent to use "Your style of learning and thinking" in your doctoral thesis as per our telephone conversation of June 24, 1977. As mentioned, we would like to receive the scores for each subject administered YSOLAT for inclusion in our normative data for the upcoming revision of the Manual. Data from the sample you described will be particularly useful as we have few blacks, and no Puerto Ricans in our sample as yet. Appropriate acknowledgement of your cooperation and assistance will, of course, be made. We would also appreciate receiving a copy of the research report produced from your study. oops!

I also thought you might be interested in the results from a group of Mime students tested last week in Buffalo on YSOLAT. As we had predicted, only moreso, no one scored less than 2 SD's above the mean for the R-hemisphere score. Although the group was small (around 30), we find this quite encouraging from a validity standpoint. Good luck with your studies. Feel free to contact me if I can be of further help. I can generally be reached at one of the two phone numbers below.

Sincerely,

Cecil R. Reynolds

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CRR:jas

MICHIGAN STATE UNIVERSITY EAST LANSING · MICHIGAN 48823

DEPARTMENT OF URBAN AND METROPOLITAN STUDIES · COLLEGE OF URBAN DEVELOPMENT

August 3, 1977

Ms. Sally Coppus
51 Bridge Road
Florence, MA 01060

Dear Ms. Coppus:

This will confirm our telephone conversation giving you permission to use our "Michigan State General Self-Concept of Ability" scale in your research on upward bound students.

I would appreciate having a copy of this report when it is completed.

Cordially yours,

Wilbur B. Brookover

WBB:cr